INFORMATION

Elementary Electricity
Motor Car Electric Systems
The Gas Engine from an Ignition
Point of View
Driving the Car

HARVEY F. PHILLIPS

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FORMERLY

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Elementary Electricity

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BY
HARVEY E. PHILLIPS

Price, $2.50

AUTO ELECTRIC SYSTEMS PUBLISHING CO.
DAYTON, O.

PREFACE

The purpose of this book is to present in a compact, convenient form, at a price within the reach of all, a reasonably comprehensive and thorough training course for teachers and students in mechanics' training schools; also repairmen and owners who desire to learn.

It is hoped that this book will be found to meet the need for a more adequate course, which is at the same time brief. To those who have been accustomed to the use of outline courses, this book will be very helpful. It will be found that the form of the lessons lends itself readily to adaptation to class work, and it is believed that the course will be found practicable for use in class work.

It is the earnest hope of the author that the book will appreciably aid in the greatly needed and the exceedingly important work of preparing men for certain lines of work.

The author gratefully acknowledges his obligation to Mr. James M. Copland, Chief Instructor Army Schools, St. Paul, Minn.; Professor C. G. Arthur, Detroit Institute of Technology, Detroit, Mich., and the Remy Electric Company, of Anderson, Ind., for valuable criticisms, suggestions, and matter used in this book.

The price of this book is $2.50 postpaid to all parts of the United States and Canada.

HARVEY E. PHILLIPS.

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Note.—The names of cars are arranged alphabetically.

SECTION I

ELEMENTARY ELECTRICITY

ELEMENTARY ELECTRICITY

1. While we do not know what electricity is, its action is well understood, and when we come to study the natural laws under which this action takes place, we find that our difficulties are few and they are not great when the subject is presented in the proper way.

2. To understand the principles of electricity, we must first understand the meaning of many electric terms. They are not only necessary if we wish to understand our subject, but they are such that when we have grasped their full meaning, we have grasped the subject itself. They are the links that we have to forge before we can make a chain, and when they are once forged, they form the chain itself.

3. In magnetism, we have a very important thing. Something invisible like electricity, easy to understand and use, and controlled by a few simple laws. While electricity and magnetism are two different things, their relationship to each other is very interesting.

4. Let us suppose that all magnetism was to cease to exist. The result would be that all of our electric power plants would become useless, because the generator must have its magnetic field before it can generate a current of electricity. In the operation of electric apparatus magnetism plays one of the greatest parts.

5. Electricity for our purpose may be looked upon as existing in two conditions, these being a state of no pressure and a state of pressure. A comparison is often made of the action of water and electricity when it is necessary to make the subject clear.

6. If we had a large body of water, such as a sea or lake, as a means of power, it is useless; that is, it has no pressure unless we let some of it fall to a lower level, in which case the water that falls loses its head or pressure, and in so doing it gives up the energy that was in it; or, to put it more clearly, it does a certain amount of work, depending upon the quantity that falls and the distance through which it travels.

7. In a similar way we may say that electricity exists in a state of no pressure, but we can give it pressure by means of a generator, and when we allow the electricity to escape, as we may term it, it gives up its pressure, then it is like water, giving up energy and doing work.

8. The amount of work that can be done depends upon the pressure and the rate current flows. We know that electricity is invisible, yet there is pressure behind it in one state and it flows under this pressure.

9. We cannot measure the rate or flow in gallons per hour as we do in water system; instead, we measure the rate it flows in amperes. We have said the electricity to flow must have pressure behind it. In a water system water flows under a certain number of pounds of pressure. In an electric system, current flows under a certain number of volts pressure.

10. When a wire or any substance is used to transmit current from one place to another it is called a conductor. These conductors offer a resistance to the flow of electric current; therefore, we must have some means of measuring this resistance. The resistance offered to the flow of current depends upon the kinds of metal used as a conductor, its area and length. The ohm is the unit of electric resistance.

11. The three terms just mentioned: the volt, as the unit of electric pressure; the ampere, as the unit of electric current, and the ohm, as the unit of electric resistance, are related to one another, this relationship being known as Ohms Law, which is as follows:

12. Volts divided by Amperes equals Ohms.
Volts divided by Ohms equals Amperes.
Amperes multiplied by Ohms equals Volts.

MECHANICAL PRINCIPLES.

13. To thoroughly understand the principles of electricity it is necessary to know first of all the meaning and application of the fundamental mechanical principles.

14. Nothing can be accomplished without expending energy. In other words, energy must be expended when any work has to be done.

15. The subject of energy should be carefully studied, because all work of whatever kind is based on the principles or laws governing the transformation and transmission of energy.

16. Energy cannot be created, nor can energy be destroyed. When energy is used up in doing work, it is simply transformed into other forms. For example, when a gas engine is running, it depends upon the fuel as to how long it will run. In this case, we say that the fuel has a certain amount of energy stored up in it, and a gas engine is simply a device which is designed to take energy from the fuel and transform it into mechanical motion.

17. This mechanical motion is represented by the turning of the crank shaft. A gas engine, therefore, is fundamentally an energy transformer. It receives energy in the form of stored fuel energy and transforms part of it into mechanical motion. In no case is it possible to transform all of the energy into useful work. Any heat formed and radiated represents a certain amount of lost energy. Friction also causes a further loss.

18. When we come to consider electricity, we will see that it is only energy in another form, or rather a means of transmitting energy.

19. **Work.** When work is done, energy is expended. For example, if a weight is resting on the table it possesses energy which can be expended only if the weight is allowed to fall. The amount of energy that the weight is capable of expending depends on two things:

(a) The amount of weight.
(b) The distance the weight falls.

20. In this case the amount of work done by the weight in falling is equal to the energy expended.

21. Another important fact that must be noted here, namely, that the work done by the weight in falling is exactly equal to the amount of work that must be done in order to replace the weight on the table.

22. **Measurement of Work.** If we assume the weight to be one pound, and the distance to be one foot, we say that the work done is one foot pound.

23. That is to say, a weight of one pound is capable of doing one foot pound of work when it falls through a distance of one foot.

24. Also an amount of work equal to one foot pound must be done in order to raise a weight of one pound through a vertical height of one foot.

25. The foot pound, therefore, is taken as the unit for measuring Work and Energy in a mechanical form.

26. Note the following example of a moving weight:

If the weight is attached to the string of a clock, it will move down slowly and so drive the mechanism of the clock. Work is being done as long as the Weight is in **Motion.**

27. When the weight gets to the bottom is must be raised again, and work must be done in **Moving the weight up.**

28. A certain amount of **Energy,** therefore, has to be expended in winding the clock, and the weight may be considered as a means of storing this energy. When the weight has fallen again to its lowest position, it has delivered an amount of energy exactly equal to the amount expended in raising it.

29. If the weight is ten pounds and the distance is three feet, the amount of work is 10 multiplied by 3, or 30 foot pounds.

30. How much work must be done to raise a weight of 55 pounds to a height of 10 feet?

55 multiplied by 10 equals 550 foot pounds (usually written this way, $55 \times 10 = 550$ foot pounds). It must be noted here that it is not necessary to actually have a weight of so many pounds. A **Force** (or pressure) gives the same result, if it causes motion.

31. Work, therefore, can always be calculated if we know the weight, force, or Pressure and the Distance through which it acts. This can be written in the following way:

Weight of force or pressure (measured in pounds)	Multiplied by	Distance (measured in feet)	Equals	The amount of work (measured in foot pounds)

32. Power. No mention has been made yet of the length of time it takes to do a certain amount of work. The reason for this is that the time taken to do work makes no difference in the amount of work done. If a weight of 10 pounds has to be raised through a height of 5 feet, it will take 50 foot pounds of work to do it. The time spent in doing work may be a second or it may be a minute, but the amount of work remains the same.

33. When time is taken into consideration in connection with doing work, it determines the **Rate** at which **Work** is done.

Suppose two men start out to do the same amount of work. One man finished in 4 hours, while the other man takes 8 hours. We would say that the first man was working twice as fast as the second man because he did the job in **half the time.**

34. Another way of looking at it would be to figure that if the first man kept on working for 8 hours at the same **Rate** as during the first 4 hours, at the end of 8 hours he would have done twice as much work as the second man in the same **Time.**

35. It is quite apparent that the rate at which he is **doing work** is **twice** as great as the rate at which the other man is doing work.

36. The **rate of doing work** is a measure of the **Power** developed.

37. If a weight of 55 pounds is raised 10 feet in one second. work is being done at the rate of 55 times 10 divided by 1, or 550 pounds per second.

This can be written $\frac{55 \times 10}{1} = 550$ foot pounds per second.

38. If the same weight is raised the same distance in two seconds, work is being done at the **rate** of 55 times 10 divided by 2, or 275 foot pounds per second.

Also written $\frac{55 \times 10}{2} = 275$ foot pounds per second.

39. In this case the rate of doing work (Power) is just one half as much as in the first case. To illustrate this, suppose the distance between two places is 12 miles. One man walks this distance in 6 hours. The rate at which he walks is divided by 6 (or $12 \div 6) = 2$ **miles per hour.**

40. Another man walks the 12 miles in 3 hours, just half the time of the first man. The rate at which he walks is 12 divided by 3 (or $12 \div 3) = 4$ miles per hour. His rate is twice as great as that of the first man because he covered the same distance in half the time. The distance corresponds to the amount of work that has to be done, and the rate of walking corresponds to the rate at which the work is done.

41. While the amount of **Work** is the same for both men, the **Rate** at which one man works is just twice that of the other man, because he does the same amount of work in half the time.

42. Measurement of Power. We have seen the unit of measurement of **Work** is the Foot Pound, which is equal to the lifting of one pound through a height of one foot. If it takes one second to perform this amount of work, the **rate is one foot pound in one second,** or one foot pound per second.

43. When the word "per" is used, it indicates **Rate.** (5 miles per hour is a rate of movement. 20 cents per gallon is a rate of cost.) One foot pound per second is a very small unit, so a larger unit is usually taken for the measurement of **Power**. For example:

44. When an amount of work equal to 550 foot pounds is performed in one second, **Work** is done at the **Rate** of 550 Foot Pounds per second. This is called **one Horsepower,** just in the same way that we take 5,280 feet and call this distance one mile.

45. Equal amounts of work may be performed in a number of different ways. For example, 10 pounds raised 55 feet equals 550 Foot Pounds.
11 Pounds raised 50 feet equals 550 Foot Pounds.
55 Pounds raised 10 feet equals 550 Foot Pounds.
550 Pounds raised 1 foot equals 550 Foot Pounds.

46. And if the time taken is one second in each case, the same power is required.

47. How many horsepower would be necessary to raise a weight of 500 pounds to a height of 110 feet in 10 seconds?

The total amount of work to be done is

$500 \times 110 = 55,000$ foot pounds.

This has to be done in 10 seconds, so we divide the 55,000 by 10.

This gives the rate, or $\frac{55,000}{10} = 5,500$ Foot Pounds Per Second.

48. One Horsepower is required when work is done at the rate of 550 foot pounds per second, so dividing 5,500 by 550 gives the number of Horsepower required to do 5,500 foot pounds per second.

$\frac{5,500}{550} = 10$ Horsepower.

Note that if the work had to be done in 5 seconds (half the time) the answer would be 20 Horsepower (twice the rate).

49. The answer can be arrived at in a slightly different way and it is very important to notice the difference. For instance, the Distance divided by the time ($110 \div 10$), or 11 feet per second, is the "Rate of Movement" of the weight. If a weight of 500 pounds moves at the rate of 11 feet per second, the power expended in moving it is equal to 500×11, or 5,500 foot pounds per second.

50. The result, therefore, may be written as follows:

Weight force or Pressure	Multipled by	Rate or Movement	Equals	Power.

51. It should be noted here that instead of actually using a weight, we can get the same results by using a Pressure or Force. For example, a Force or Pressure acting upon the piston of an engine causes the piston to move, and work is done. The rate at which the work is done is a measure of the power of the engine.

54. Rate of Movement. If a weight of 500 pounds is moved at the rate of 11 feet per second, the power expended in moving it is equal to 500×11, or 5,500 Foot Pounds per second, which is the same result as before.

55. It is very important to note the above result and the reasoning leading up to it. Reference will be made to it again in dealing with the Fundamental Principles of Electricity.

MECHANICAL UNITS AND TERMS.

56. Work. The overcoming of resistance through a certain distance, force times the distance through which it acts.

Weight times the distance through which the weight falls or is raised. **Energy**—Work in a stored form. The ability to perform work. This energy, stored in a tank of water, represents the amount of work the water will have done in falling a certain distance. Also the amount of work that would have to be done to put the water back into the tank.

57. Power. The rate of doing work.

58. Foot. A unit of distance.

59. Pound. A unit of weight, force, or pressure.

60. **Second.** A unit of time.

61. **Foot Pound.** A unit of work. The lifting of one pound through a height of one foot. A Pressure of one pound exerted through the space of one foot.

62. **1 Foot Pound Per Second.** The Unit of power. The lifting of one pound to a height of one foot in one second.

63. **Horsepower.** A larger unit of power. Doing work at the rate of 550 foot pounds per second.

QUESTIONS

1. Do we know what electricity is? What is known of its action?
2. What should first be learned in studying electricity?
3. What may be said of the relation between magnetism and electricity?
4. What would result if all magnetism should cease to exist?
5. With what may the action of electricity be compared?
6. How is power produced in a water system?
7. What is the purpose of a generator?
8. The amount of work that can be done electrically depends on what?
9. How is electric pressure and rate of flow measured?
10. What determines the resistance of a conductor?
11. Define the terms Volt, Ampere, and Ohm.
12. Give Ohms law.
13. Why should mechanical principles be understood?
14. What must be expended before work can be done?
15. Why should the subject of energy be carefully studied?
16. Can energy be created?
17. What is a gas engine?
18. What is electricity?
19. How may the amount of energy stored in a weight be determined?
21. How may we store energy in a weight?
22. Explain the term "Foot Pound."
25. The foot pound is the unit of what?
26. When is work being done?
28. How much energy must be expended to wind a clock?
30. How much work must be done to raise a weight of 55 pounds to a height of 10 feet?
31. How may work be calculated?
32. What may be said of time taken to do work?
33. Give a comparison in rate of doing work.
37. Give table for determining rate of doing work.
42. What is the unit of measurement of work?
43. Give meaning of the word "Per."
47. How many Horsepower would be required to raise a weight of 500 pounds to a height of 110 feet in 10 seconds?
56. Explain the term "Work"; "Energy."
57. Define the term "Power."
58. Define the term "Foot."
59. Define the term "Pound."
60. Define the term "Second."
61. Define the term "Foot Pound."
63. Define the term "Horsepower."

ELECTRICAL PRINCIPLES

64. When we consider electricity it should be kept in mind that we are not concerned with the nature of electricity, but rather with the laws which govern its action. Electricity, of course, is invisible, yet we can study its effects just as well as if it could be seen. We must, of course, assume certain things about electricity, but as long as nothing comes along to prove our assumptions to be wrong, we may continue to use them in explaining the action of electricity.

65. It is also useful to compare the action of electricity with the action of water, with which everybody is more or less familiar. Let us assume, first, that electricity is something that flows or moves. We can then say that if it flows it must have a rate of movement (or flow). (Electricity is usually spoken of as flowing in a circuit.)

66. Comparing this with water, note that we usually measure the flow of water by noting how much water flows in a given time. For example, if 10 gallons flow past a certain point in one minute, we say the water is flowing at the rate of 10 gallons per minute.

67. Rate of Flow. We measure the rate of flow of electricity also by taking the quantity that flows in a given time. Instead of using the quantity unit and the time unit to express the rate of flow as in the case of water, we take one word to include both. We use a new name for it and say the rate is measured in amperes. Note that we never say "one ampere per second" or "one ampere per minute," etc. **The rate of movement of flow of electricity** is measured in amperes.

68. Pressure. Before anything can move, it is necessary to have some force or pressure applied to it. This holds true with regard to all material or physical bodies and we can assume that it applies to electricity also.

69. We measure the pressure of water or steam by pressure gauge which is made to show pounds per square inch.

70. An electrical pressure gauge is called a Voltmeter, and is marked to show volts.

71. The word "volt" need be no more mysterious than the words "pound" or "inch." We measure weight in pounds and distance in inches, yet very few people could ever say why we use "pounds" and "inch." All we have to remember is that whenever "volts" are mentioned it means the measurement of the electrical pressure.

72. Electricity is a means of transmitting energy. By this we mean that work can be done by the use of electricity, and the way in which this is brought about is not very hard to understand.

73. Laying electricity aside for the present, let us consider water with which we are more familiar. If we connect a pipe to a water motor and then turn on the water, the motor will operate and deliver energy. The energy does not come from the pump but from the water, and to follow this line of thought further, we find that the energy is due to the fact that the water is in motion.

74. Going still further, we would ask, What gives the water its motion? Where does the energy come from? Water will not move unless there is a force making it move. Where does this force come from?

75. There are two ways in which this force can be procured, or to say the same thing correctly, there are two ways of imparting or giving **Energy** to water.

76. First, by allowing the water to fall from a high level to a lower level. When the water has reached the lowest level it gives up its energy either in doing useful work, as in the case where we make it flow through a water motor, or the **Energy** is simply wasted, as in the case where the water strikes the ground and forms a pool.

77. Why do we continue to have plenty of water flowing in our rivers and over the natural water-falls? There is only one answer. The sun is the agent that raises the water again and in doing so gives to it what we call **Energy** or the capacity for doing work. It should be noted at this point that the water has moved in a complete circle or circuit, as follows:

78. Starting from a low level—represented by the sea or a lake—it is evaporated by the heat from the Sun and raised up in the air. It becomes condensed and forms clouds, when it falls back to the earth in the form of rain or snow. The rain or snow that falls on the high levels—the mountains—forms small streams. These run together and become rivers, gradually descending to the lower levels.

79. When the water takes a sudden drop as in the case of a waterfall, it gives up the Energy it possesses, due to the difference in height between the top of the waterfall and the bottom. After some of this Energy has been used in doing useful work as previously described, the water returns again to the starting point and the circle or circuit is completed.

80. The second way of imparting or giving energy to the water is by the use of a pump. This enables us to raise the water up to a high level again and "store up" Energy. When we allow the water to fall, it gives up the energy that was stored up. It is not necessary, however, to actually lift the water each time and allow it to fall.

81. Instead we can take the water as it leaves the pump, when it will be under a certain pressure, and lead it directly to the water motor. We would then get just as much energy from the water as we would if we lifted it up to a corresponding high level and let it fall again.

82. The question might be asked here, Where do we get the energy that enables the pump to raise the Water? This may be in various forms, such as animal power, steam engine, Gas or Gasoline Engine, Electric Motor, etc. All of these things are simply energy transformers.

83. That is, they change energy from one form into another. They receive energy in one form and give it up again in another. The gasoline engine must have gasoline, and the electric motor must have electricity. Animals, too, must be fed if they are to be kept alive and able to perform work.

84. Following up the Gasoline Engine as a means of operating the pump, we have traced the source of energy back to fuel. Where does the fuel get its Energy? Again we find that we are indebted to the Sun. During the long period, ages ago, when the earth was being formed, the sun was storing up energy in various forms. One of these is the crude oil from which we obtain Gasoline, Kerosene, etc.

85. The conclusion we arrive at, therefore, is that Energy is already provided for our use. We cannot create energy ourselves in any shape or form. As long as the supply lasts, we can use it in a large variety of ways. Another thing to remember is that a certain amount of energy is lost whenever it is changed from one form to another.

86. Turning now to the subject of Electricity, it has been shown that water in itself does not possess any Energy. It is only a means by which energy can be transmitted from one place to another, and we must impart motion to the water before it will transmit energy.

87. Electricity is also a means or medium by which energy can be transmitted. It does not possess any energy of its own, and it must be in Motion before any energy can be derived from it. Although electricity is invisible, yet we can understand its action very readily if we regard it as a fluid; that is, something that flows.

88. Water will flow only when there is a pressure of Head, as it is often called, to cause it to flow. In the case of water delivered from a force pump, the pressure is obtained from the moving plunger. In the case of water from an open tank, we can only put the water in motion by having the tank at a high level and allowing the water to flow, due to gravity, to a lower level.

89. We do not manufacture electricity any more than we do the water or the air we use. We might say that electricity exists everywhere, but it is not in motion; therefore, we are not aware of its presence. We might compare it with the air in this way.

90. When it is not in motion we call it air and are hardly aware of its presence; when it is in motion we call it wind, and it can be made to perform work by operating a windmill.

91. By means of an electric generator (which is more fully described later) we can generate or collect some of the electricity and put it in Motion.

92. The Electric Generator (as we will call it in the future) does the same thing to electricity that the water pump does to the water. It collects electricity and forces it through the wires or conductors. Its effects can then be studied, and by means of suitable devices—lamps, electric motors, electric heaters, etc.—we can make use of the electricity in Motion.

93. When electricity has been used in operating one of these devices, we have simply used it as a means of transmitting Energy from one place to another. The Energy is used up in operating the lamp, motor, or other devices. The electricity loses its motion, and therefore has no more power or ability to do any further work.

94. A closed path or Circuit is necessary before electricity can flow. That is, it must return to the starting point. Fig. 1, page 17, shows a water system in which "A" is a rotating pump and "C" and "D" the pipes, and "B" is a water motor. This whole system is filled with water. When the pump "A" is caused to rotate water will be forced through the pipe "C" through the water motor "B", causing it to rotate and return through the pipe "D." This completes the water circuit. By means of the water in motion, energy is transmitted from the pump to the motor; where it can be converted into useful work in a number of (mechanical) ways.

95. Fig. 2, page 17, illustrates an electric system in which "A" is an electric generator, "C" and "D" the wires, and "B" an electric motor. When the generator is caused to rotate it forces a current of electricity through the wire "C," through the motor "B," returning to the generator through the wire "D." This completes the "electrical" circuit.

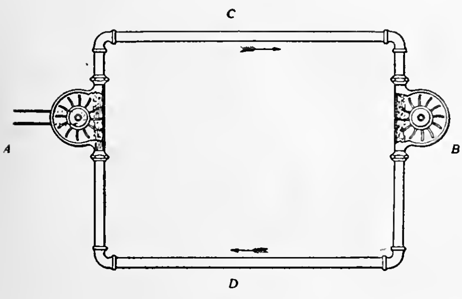


Fig. 1

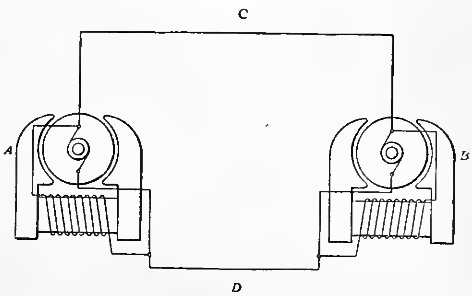


Fig. 2

96. By means of the electricity in motion, energy is transmitted from the generator to the motor, where it can be converted into useful work in a number of (mechanical) ways. The wire "C" is called the positive side of the circuit, often indicated by the sign "+". The wire "D" is called the negative side of the circuit, often indicated by the sign "—".

97. The terms positive (+) and negative (—) simply indicate the direction. The terminal on a generator from which current flows is the Positive Terminal. The terminal through which the current returns to a generator is the Negative Terminal.

98. The terminal on a motor by which current enters is the Positive Terminal. The terminal on a motor from which current leaves is the Negative Terminal. Again, the part of a circuit used for the delivery of current is the Positive side. The part used for the return of current to the source is the Negative side.

99. Two things govern the amount of power which can be transmitted by the water system of Fig. 1. First, the pressure with which the water is forced through the pipes, and second, the size of the nozzle at the motor.

100. The size of the nozzle governs nothing more than the amount of water which will flow through this hole in a given time; the smaller the hole, the less would be the amount of water which would flow through. In other words, the two things which govern the amount of power transmitted by this water system are, first, the pressure, and second, the rate of flow.

101. This principle is used in figuring the amount of power which can be obtained from the water-fall. If the water-fall is not very high, a large quantity of water would be required to furnish a given amount of power; if, on the other hand, the fall is extremely high, the same amount of power could be obtained from a small amount of power, if the pressure is increased, then the amount of water flowing must be decreased and vice versa.

102. To make the above clear, Fig. 3, page 18, in which "A" represents a pump and "B" a motor. At "G" is shown what might be called a pressure meter, which is connected to "C" and "D." The meter consists of a cylinder with a piston; behind the piston is a spring. When the pump is standing still, the pointer of the meter would stand at zero. If the pump is turned, it will cause the pressure in the pipe "C" to rise.

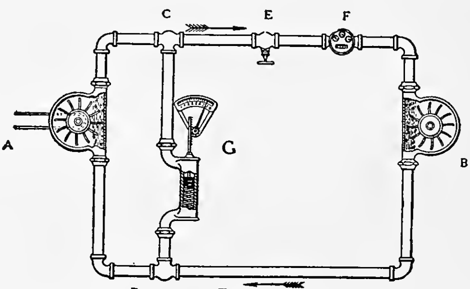


Fig. 3

103. This would press down the piston of the meter "G" and move the hand over the dial, thus indicating the difference in pressure between the two pipes. This pressure does not indicate the amount of power, as the valve at "E" may close. If the valve is opened and the water is allowed to flow through, the motor will turn. At "F" is placed a meter like the ordinary house meter, and measures the amount of water which flows through the pipe.

104. In this way the amount of power which is transmitted by this system can be determined. Both the pressure and the amount of water flowing must be known. Suppose the water motor is used to drive a small fan and it requires a pressure of 10 pounds, as indicated on the meter "G," and a gallon of water per second flowing through the meter "F."

105. Now if the pressure can be raised to 20 pounds, a smaller nozzle can be used on the water motor; in this case the pressure has been doubled and therefore the quantity of water which is needed to run the motor would be only one half as much. The meter "F" would show only one half the number of gallons per minute. If, however, the pressure was reduced to five pounds, the amount of water flowing through the motor would have to be increased to double that which is required for 10 pounds pressure.

106. In Fig. 4, page 19, is given an illustration of an electrical system of transmitting

power. This system consists of a generator, a motor, and two meters, the functions of which will be explained later.

107. At "G" is a meter corresponding to the pressure gauge in the water system. If the circuit at "E" was open, and the generator turned, their pressure meter would show the difference in the electrical pressure between the two wires.

108. The motor will not run, however, until the switch is closed, but just as soon as this is done, the current will begin to flow and thus operate the motor. In our water system the rate of flow is measured with a meter at "F." In the electrical system (Fig. 4) the rate at which the current is flowing is measured by a similar electric meter at "F."

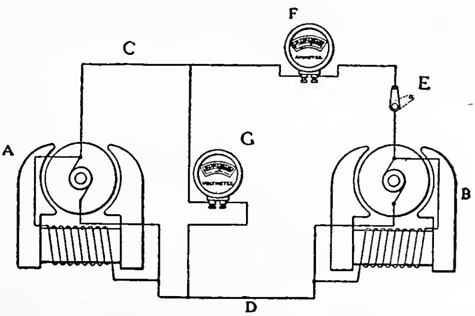


Fig. 4

109. Pressure multiplied by rate of movement equals Power. In dealing with electricity the same thing is true. Electrical pressure is measured in Volts, and the rate of movement of the current in Amperes. Volts multiplied by Amperes, therefore, gives the Power.

110. An example will help to make this clear. If current flows at the rate of one **Ampere,** and the pressure causing it to flow is one volt, Power is being delivered at a definite rate.

111. Power is measured then by the **Rate** at which it is being delivered or used. When current flows at the rate of 1 Ampere with a pressure of one Volt, power is being delivered at the rate of 1 **Watt. The Watt** is nothing more than a measurement of the **Rate** at which **Power** is used or produced.

112. To measure the power produced or used, take the rate of flow in Amperes and multiply this by the pressure in Volts. 10 Amperes flowing in a circuit where the pressure is 32 Volts means that Power is being delivered at the rate of 320 **Watts.**

($10 \times 32 = 320$ **Watts.**)

113. When 1000 Watts are being delivered, the word **"Kilowatt"** is used. (**Kilo** is a Greek word meaning a thousand.) (1000 **Watts** = 1 Kilowatt or 1 K. W.)

114. The relationship between the mechanical measurement of power and the electrical measurement of power must be remembered, namely:

746 **Watts** equal one Horse Power.
This can also be stated:
1 K. W. equals $1\frac{1}{3}$ H. P.
or 1 H. P. equals $\frac{3}{4}$ K. W.

VOLTAGE DROP

115. When electricity flows through a wire (or conductor), the wire offers some resistance to the current. This means that some of the pressure or Voltage is used up in overcoming the resistance of the wire. The amount of voltage lost in this way, or the difference between the voltage at the source of supply and the voltage at the point where current is used, is known as Voltage Drop.

116. Where water is flowing through a pipe to a distant point, the pressure is less at the point of delivery than at the source. When electricity is flowing through a conductor (wire) to a distant point, the pressure (voltage) is less at the point of delivery than at the source.

117. It should be noted that in order to measure the voltage drop, the current to be used must be flowing at the time when the voltage is being measured. If a voltmeter is used at the end of a line when current is not flowing, the voltage reading will be practically the same as at the source.

118. The amount of resistance in a wire depends upon three things: (1) The material. Copper is a better conductor than iron, which is the same as saying that the resistance of copper is less than the resistance of iron.

(2) The area or cross section of the wire. A large wire offers less resistance to the flow of electricity than a small wire.

(3) The length of the wire. For example, 100 feet of No. 10 wire has twice the resistance of 50 feet of No. 10 wire.

QUESTIONS

64. Can we see electricity?
65. With what can the action of electricity be compared?
66. Give a comparison.
67. How is rate of flow of electricity measured?
68. What may be said of force or pressure?
69. How is water or steam pressure measured?
70. What is a voltmeter?
71. Weight is measured in what? How is electric pressure measured?
72. Give the use of electricity.
73. Explain how power is produced by a water system.
77. Why do we continue to have water flowing in the rivers?
80. How can energy be given to water?
82. Where do we get the energy used to operate a pump and raise water?
83. How long will a gasoline engine run?
84. Where does the fuel get its energy?
85. Can we create energy?
86. Does water possess energy?
87. Does electricity possess energy of its own?
89. Do we manufacture electricity?
90. Is there any difference between air and wind? Explain this.
91. How can we collect electricity?
92. Name some devices operated by the use of electricity?
94. How is energy transmitted from the water pump to the water motor?
95. How is energy transmitted from the electric generator to the electric motor?
97. What do the terms "positive" and "negative" indicate?

99. What governs the amount of power which can be transmitted by a water system?

102. To what is the pressure meter connected? What is it for?

104. Why must the pressure and rate of flow be known?

105. Name the instruments used to measure water pressure and rate of flow.

106. Name the instruments used to measure electric pressure and rate of flow.

107. Volts multiplied by Amperes equals what?

111. Define the term "Watt."

113. Define the term "Kilowatt."

114. Give relationship between mechanical measurements of power and electrical measurements of power.

118. What determines the resistance of a conductor?

WIRE SIZES AND DROP

1. A conductor offers a resistance to the flow of current, and when current flows through the conductor a certain amount of pressure is lost in overcoming this resistance.

2. The greater the distance current flows through a conductor the greater the loss of pressure. This is known as volts drop. See Figs. 1, 2, 3, and 4, page 24.

3. If we have a boiler with the gauge showing 100 pounds pressure and an engine 200 feet away that is to be operated by this steam, the pressure of the steam at the engine end of the pipe will be less than 100 pounds.

4. The farther away we take the engine from the boiler, the greater the loss of pressure to the engine, or the greater the pressure drop.

5. The resistance of a piece of wire depends upon three things: First, the kind of metal in the wire. Copper offers less resistance to the flow of current than iron. Second, the area or size of the wire.

6. The larger the wire the less the resistance to the flow of current. Third, the length of the wire. The longer the wire the greater the resistance offered to the flow of current.

7. The size of a wire to use in a circuit depends upon the amount of current that must flow and the length of the wire.

8. If two number 10 wires made of copper are run for a distance of 1,000 feet, and a lamp that consumes one-half ampere of current is connected across the ends of the wires, there will be a drop in pressure in carrying the current this distance.

9. If the pressure of the source is 110 volts, the pressure of the current at the lamp will be 109 volts. This resistance offered to the flow of current is one ohm per 1,000 feet when number 10 wire is used.

10. The two thousand feet of number 10 wire used in this case offers 2 ohms of resistance. (To find voltage drop, multiply ohms resistance by Amperes flowing.) Then 2 ohms resistance times one-half ampere is equal to one volt drop.

11. If ten of the same sized lamps are connected across the end of these wires in the place of the one lamp, the drop in pressure will be much greater. The 10 lamps will consume 5 amperes of current. Then 2 ohms times 5 amperes equals 10 volts drop.

12. This means that the pressure across the lamps will be only 100 volts, and the lamps will burn dim, due to the great drop in pressure. In this case the pressure drop is about 9%.

13. A conductor must be large enough to carry the desired amount of current to a certain point with less than 5% drop.

14. In the cranking circuit the drop should be held to not over 2%.

QUESTIONS

1. What results when current flows through a conductor?
2. What is meant by "Volt Drop"?
3. What is meant by drop in steam pressure?
5. Upon what does the resistance of a wire depend?
7. Upon what does the size of a wire depend?
9. What is the resistance of 1,000 feet of No. 10 copper wire?
10. How is voltage drop determined?
11. What regulates the drop in voltage?
12. Why will the lamps burn dim?
13. How much drop is allowed?
14. How much drop is allowable in a cranking circuit?

OHMS LAW

Volts divided by Amperes equals Ohms.
Volts divided by Ohms equals Amperes.
Amperes multiplied by Ohms equals Volts.

WATT LAW

Watts divided by Amperes equal Volts.
Watts divided by Volts equals Amperes.
Volts multiplied by Amperes equals Watts.

EXAMPLES

Q. If current under 110 volts pressure flows through a circuit at a 10-Ampere rate, what is the resistance of the circuit? A. 110 (Volts) divided by 10 (Amperes) equals 11 Ohms resistance.

Q. If current under 32 Volts pressure flows through a circuit at a 4-Ampere rate, what is the resistance of the circuit? A. 32 (Volts) divided by 4 (Amperes) equals 8 Ohms resistance.

Q. The resistance of a circuit is 24 Ohms and the pressure upon the current flowing is 32 Volts. What is the rate of flow of current in Amperes? A. 32 (Volts) divided by 24 (Ohms) equals 1⅓ Amperes.

Q. The resistance of a circuit is 55 Ohms and current flows at a 2-Ampere rate. What is the pressure upon the current in volts? A. 2 (Amperes) multiplied by 55 (Ohms) equals 110 Volts.

Q. The resistance of a circuit is 16 Ohms and current flows at a 2-Ampere rate. What is the pressure upon the current in Volts? A. 2 (Amperes) multiplied by 16 (Ohms) equals 32 Volts.

Q. If current under 100 Volts pressure is being consumed at the rate of 1100 Watts per hour, what is the rate of flow in Amperes? A. 1100 (Watts) divided by 110 (Volts) equals 10 Amperes.

Q. If current under 32 Volts pressure is being consumed at the rate of 352 Watts per hour, what is the rate of flow in Amperes? A. 352 (Watts) divided by 32 (Volts) equals 11 Amperes.

Q. Current under 110 Volts pressure is flowing through a circuit at a 5-Ampere rate. How many Watts will be consumed in 4 hours? A. 110 (Volts) multiplied by 5 (Amperes) equals 550 Watts per hour. 550 (Watts) multiplied by 4 (hours) equals 2200 Watts.

Q. Current under 32 Volts pressure is flowing through a circuit at a 7-Ampere rate. How many Watts will be consumed in 4 hours? A. 32 (Volts) multiplied by 7 (Amperes) equals 224 Watts per hour. 224 (Watts) multiplied by four (hours) equals 896 Watts.

Q. Current flowing through a circuit at a 5-Ampere rate is being consumed at the rate of 550 Watts per hour. What is the pressure in volts? A. 550 (Watts) divided by 5 (Amperes) equals 110 Volts.

Q. Current is flowing through a circuit at a 9-Ampere rate, and is being consumed at the rate of 288 Watts per hour. What is the pressure in Volts? A. 288 (Watts) divided by 9 (Amperes) equals 32 Volts.

Q. If a 110-Volt motor consumes current at an 8-Ampere rate, how many Watts will be consumed in 5 hours? A. 110 (Volts) multiplied by 8 (Amperes) equals 880 Watts per hour. 880 (Watts) multiplied by 5 (Hours) equals 4400 Watts.

Q. If a 110-Volt motor consumes current at a 10-Ampere rate, how many Kilowatts will be consumed in 10 hours? A. 110 (Volts) multiplied by 10 (Amperes) equals 1100 Watts per hour. 1100 (Watts) multiplied by 10 (Hours) equals 11,000 Watts. 11,000 (Watts) divided by 1000 (1000 Watts equal one Kilowatt) equals 11 Kilowatts.

Q. If a 32-Volt motor consumes current at a 10-Ampere rate, and current costs 3 cents per Kilowatt, what will it cost to operate it for 100 hours? A. 32 (Volts) multiplied by 10 (Amperes) equals 320 Watts per hour. 320 (Watts) multiplied by 100 (Hours) equals 32,000 Watts. 32,000 divided by 1000 equals 32 Kilowatts. 32 Kilowatts at 3 cents per Kilowatt equals 96 cents.

Q. If twelve 32-Volt lamps consume current at a 24-Ampere rate, what is the average Wattage per lamp? A. 24 (Amperes) divided by 12 (Lamps) equals 2 Amperes per lamp. 2 (Amperes) multiplied by 32 (Volts) equals 64 Watts per lamp.

Q. What will it cost to burn five 50-Watt lamps three hours per night for 30 nights if current costs 9 cents per Kilowatt? A. 5 (Lamps) multiplied by 50 (Watts per lamp) equals 250 Watts per hour. 250 (Watts) multiplied by 3 (Hours per night) equals 750 Watts per night. 750 (Watts) multiplied by 30 (Nights) equals 22,500 Watts. 22,500 divided by 1000 equals 22½ Kilowatts. 22½ multiplied by 9 equals $2.025.

Q. If it costs one dollar to burn four 50-Watt lamps for 100 hours, what is the cost per Kilowatt? A. 4 multiplied by 50 (Wattage per lamp) equals 200 Watts per hour. 200 (Watts) multiplied by 100 (Hours) equals 20,000 Watts. 20,000 (Watts) divided by 1000 equals 20 Kilowatts. $1.00 divided by 20 (Kilowatts) equals 5 cents per Kilowatt.

Q. If a gas engine driving a 32-Volt, 20-Ampere generator will run five hours on a gallon of kerosene which costs 10 cents per gallon, what is the cost of current per Kilowatt? A. 32 (Volts) multiplied by 20 (Amperes) equals 640 Watts output per hour. 640 (Watts) multiplied by 5 (Hours) equals 3,200 Watts. 3,200 (Watts) divided by 1000 equals 3.2 Kilowatts. 10 (Cents) divided by 3.2 (Kilowatts) equals 3.1c+.

VOLTAGE DROP

Ohms multiplied by Amperes equals Volts drop.
Volts drop divided by Ohms equals Amperes.
Volts drop divided by Amperes equals Ohms.

Q. If a 32-Volt generator is delivering current to a motor that consumes 2 Amperes and the Voltage at the motor terminals is 30 Volts, what is the resistance of the conductors (wires) between the generator and the motor? A. 32 (Volts) less 30 (Volts) equals 2 Volts drop. 2 (Volts drop) divided by 2 (Amperes) equals 1 Ohm resistance.

Q. The resistance of a circuit (wires) between a 32-Volt generator and a 32-Volt motor is .2 Ohm and the Voltage at the motor terminals is 30 Volts. What is the rate of flow of current in Amperes? A. 32 (Volts) less 30 (Volts) equals 2 Volts drop. 2 (Volts drop) divided by .2 (Ohm) equals 10 Amperes.

Q. A 32-Volt generator is delivering current to a motor which is consuming 4 Amperes and the resistance of the conductors between the generator and the motor is .5 Ohm. What is the Voltage drop at the motor terminals? A. .5 (Ohm) multiplied by 4 (Amperes) equals 2 Volts drop.

VOLTAGE DROP

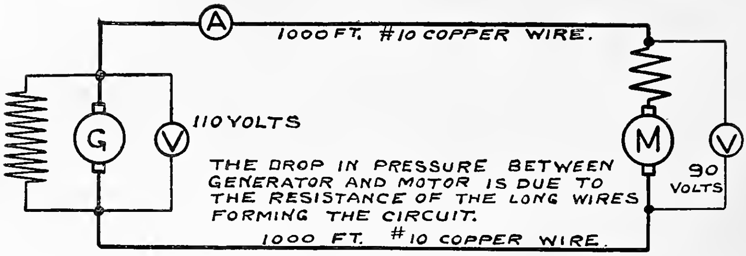


FIG. 1

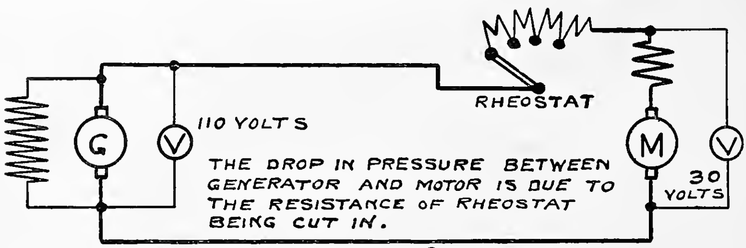


FIG. 2

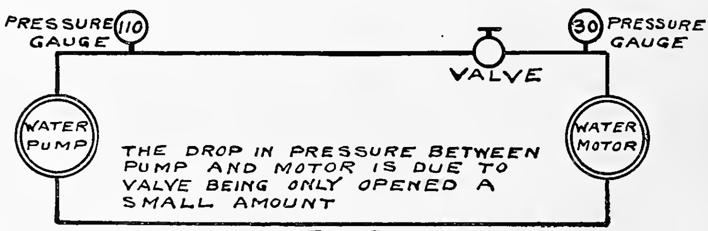


FIG. 3

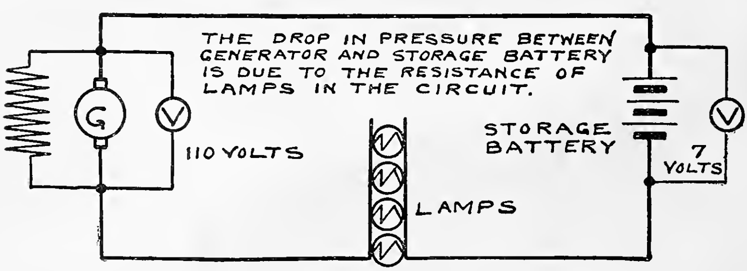


FIG. 4

Q. Two Electric fans consuming 2 Amperes each and 4 twenty-five Watts lamps are being operated from a 32-Volt battery. In how many hours will they consume one Kilowatt? A. 2 (Amperes) multiplied by 32 (Volts) equals 64 Watts per hour for each fan. 64 (Watts) multiplied by 2 (Fans) equals 128 Watts per hour consumed by the two fans. 4 multiplied by 25 (Wattage of each lamp) equals 100 Watts per hour consumed by the four lamps. 128 Watts (current consumed by fans each hour) plus 100 Watts (current consumed by lights each hour) equals 228 Watts per hour. 1000 (1000 Watts equals one Kilowatt) divided by 228 (Watts consumed per hour) equals 4.39 hours +.

Q. If a 32-Volt generator is generating current at a 20-Ampere rate and a motor, consuming 5 Amperes and four 40-Watt lamps are being operated, at what rate is the battery being charged? A. 4 (Lamps) multiplied by 40 (Watts per lamp) equals 160 Watts per hour consumed by the four lamps. 160 (Watts) divided by 32 (Voltage of the generator) equals 5 Amperes. 5 Amperes (current consumed by the motor) plus 5 Amperes (current being consumed by the lights) equals 10 Amperes being consumed by the motor and lights. 20 Amperes (output of the generator), less 10 Amperes (current being consumed) equals 10 Amperes, which is the charging rate.

MAGNETISM

1. To understand the principles of magnetism, we must first learn its action and the natural laws under which it takes place. It is invisible, like electricity, easy to use and understand, and controlled by a few simple laws.

2. Iron and steel is said to be composed of molecules (little magnets) which lie in the metal in confused positions. If an insulated wire is wound around a bar of iron or steel and a current of electricity is passed through the wire, the molecules have a tendency to straighten out in the metal parallel with each other.

3. For instance: If only a small amount of current is passed through the wire, which surrounds the core, a small portion of the molecules are affected and straighten out parallel with each other. Increasing the current flowing through the wire causes an increased number of molecules to be affected, until a point is reached where all the molecules are straightened out parallel with each other. At this point the core is said to be saturated, and an increase in the flow of current will not have any further effect.

4. If an insulated wire is wound around a core made of iron or steel and a current of electricity is passed through the wire, the core will attract other pieces of iron or steel as long as current flows through the wire.

5. This power of attraction is called magnetism. If the core of iron or steel is very soft it will lose its magnetism and the molecules will fall back in their confused positions as soon as current ceases to flow. This is called an Electro-Magnet. If the bar is of hardened steel it will retain its magnetism after current ceases to flow and will be known as a permanent magnet.

6. A permanent magnet, when placed on a pivot or suspended by a string, will turn so that one end will point to the north and the other end to the south. The hand of a compass is nothing more than a piece of hardened steel that has been magnetized.

7. The end that points to the north is called the north pole, and the end that points to the south is called the south pole.

8. If another permanent magnet is brought close to a permanent one that is suspended, the following interesting things will be observed: When the north pole of the magnet is brought close to the north pole of the suspended one, the suspended one will immediately rotate away. If the north pole of the magnet is brought close to the south pole of the suspended one, the suspended one will rotate toward it.

9. The simple laws of magnetism are: A magnet has two poles. One is called the North Pole and the other is called the South Pole. The North Pole points to the North,

and the South Pole points to the South, if the magnet is free to turn. Also that like poles epel and unlike poles attract.

10. To show attraction of unlike poles and repulsion of like poles, sprinkle iron filings on a paper. Bring two like poles up close to the paper just beneath the iron filings, keeping the poles at least an inch apart. See Fig. 7, page 27. The iron filings will present the appearance of two jets of water being forced against each other. If two unlike poles are placed beneath the paper, in the same positions as that of the like poles, the iron filings will form in strings or cords between the two unlike poles. See Fig. 8, page 27.

11. It is impossible to insulate from magnetism. Magnetism will always follow the path of least resistance to complete its circuit. Magnetic lines of force (often called flux) always pass through the core from the south to the north pole and through the air from the north to the south pole.

12. The strength of a magnet depends upon three things: The number of turns in the magnetizing coil, strength of current flowing, and the quality of the path (core) through which the magnetic flux passes.

13. Facing the dial of a clock, wind an insulated wire around the hand spindle in the direction the hands travel and pass a current of electricity through the wire in the same direction. The end of the spindle the hands are on will be the south pole and the other end the north pole.

14. Wire should always be wound around a core in the same direction. Then the polarity of this magnet will depend upon the direction current is passed through the wire.

15. Iron or steel is a better conductor of magnetism than the air, and lines of force exert their powers in the direction of shortening their travel. A piece of iron or steel, if placed within the range of the flux from a magnet and left free to move, will be pulled into the position which gives the lines of force the shortest path through it from the north to the south pole of the magnet.

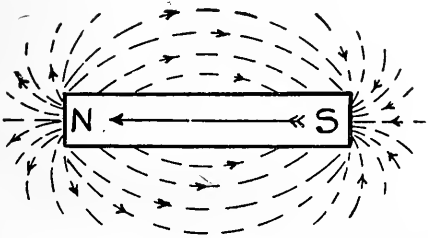
16. An armature is the moving part of an electro-magnet (called relays) or the revolving part of a motor or generator. In operation it will always be drawn into that position which gives the lines of force the shortest path from pole to pole through the armature within the range of its movement.

17. There is always a limit to the magnetic flux that can be forced through iron or steel. Beyond certain degrees of magnetization called "working points," the magnetic resistance of iron or steel increases so rapidly that a considerable increase of magnetizing power produces only a small amount of magnetism.

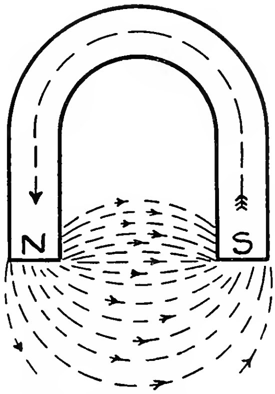
18. Then the magnets core is said to be nearing saturation. Finally a point is reached when an increase in magnetizing power produces no appreciable increase on magnetism. Then the core is saturated.

QUESTIONS

1. What is necessary to understand the principles of magnetism?
2. Name two good conductors of magnetism.
3. What results when current flows through an insulated wire which surrounds an iron core?
4. Will the core always lose its magnetism as soon as current ceases to flow?
5. What is an electro-magnet? What is a permanent magnet?
6. What is the hand of a compass made of?
7. What names are applied to the poles of a magnet?
   Which poles attract? Which poles repel?
9. Give the simple laws of magnetism.
10. Explain how attraction and repulsion can be demonstrated.
11. Give direction of flow of lines of force through magnetic material and the air.
12. Upon what does the strength of a magnet depend?
13. Upon what does the polarity of a magnet depend?



BAR MAGNET
AND
LINES OF FORCE
FIG. 5



HORSESHOE MAGNET
AND
LINES OF FORCE
FIG. 6

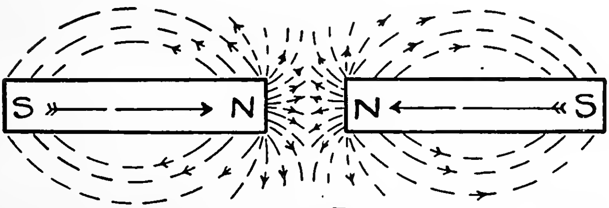


FIG. 7
REPULSION OF TWO "LIKE" POLES

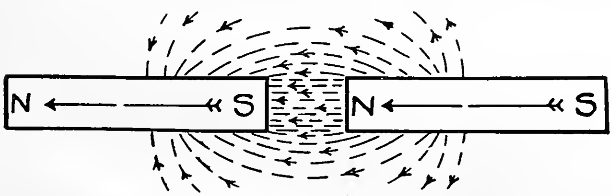


FIG. 8
ATTRACTION OF TWO "UN-LIKE" POLES

15. What results if a piece of iron or steel is placed within the range of the flux from a magnet and left free to move?
16. What is an armature? Name two kinds.
17. Is there a limit to the amount of magnetic flux that can be forced through iron or steel?
18. What is meant by Saturation?

INFORMATION

1. **Acid.** Muriatic acid is used in making soldering solution. (See Soldering Solution.)

2. **Acid.** Sulphuric acid is used in making electrolyte. (See Electrolyte.)

3. **Active Material.** A composition used in making the plates of a storage battery.

4. **Alloy.** A compound of two or more metals.

5. **Alternating Current.** Current that rapidly changes direction of flow in a circuit.

6. **Ammeter.** An instrument used to indicate the rate current is flowing.

7. **Ampere.** The unit of electric current. Rate of flow of current is measured in Amperes.

8. **Ampere Hour.** The quantity of current passed by one ampere in one hour.

9. **Ampere Turn.** A single turn or winding in a coil of wire through which one ampere passes.

10. **Anneal.** The process of softening by heating and then slowly cooling.

11. **Armature.** The revolving part of a motor or generator, the moving part of a relay.

12. **Armature Windings.** The coils of wire of an armature that are connected to the commutator.

13. **Automatic Cut-Out.** A device used to automatically open a circuit.

14. **Batteries.** Two kinds in general use. Dry cells are used where a small amount of current is required at a time. Storage batteries are used where either a small or great amount of current is required. When dry cells are discharged they are useless and discarded. When storage batteries are discharged, they may be charged again by passing a current of electricity through them.

15. **Breaker Box.** The compartment of a magneto in which the primary circuit is opened and closed. This compartment contains the breaker points and cam.

16. **Brush.** A device used to make contact with a moving part. Most commonly used to make a flexible contact to a commutator.

17. **Brush Arm.** An arm upon which a brush is mounted.

18. **Brush Arm Spring.** A spring used to give tension to a brush on a commutator.

19. **Circuit.** The course followed by an electric current from its source through conductors back to the starting point.

20. **Circuit Breaker.** An electric device used to automatically open a circuit.

21. **Circuit Diagram.** A drawing used to show the internal circuits of apparatus.

22. **Closed Circuit.** A circuit that is completed so current can flow.

23. **Closed Magnetic Circuit.** A circuit through which lines of force flow through metal only.

24. **Coil.** A single turn of wire of an Armature is called a coil.

25. **Compass.** Used to indicate directions. The needle of a compass is made of a fine piece of steel highly magnetized. This needle will point north and south if not affected by other forces. If an ordinary sewing needle is magnetized and then dipped in Oil, it will float on water and will point north and south.

26. **Commutator.** The part upon which the brushes of a Motor or generator make contact.

27. Condenser. Made of sheets of tinfoil, separated from each other and connected across places in an electric circuit where the circuit is opened. It is often used to eliminate burning of contact points. In an ignition system it is also used to assist the induction coil in increasing voltage.

28. Conductor. Any substance through which a current of electricity will flow.

29. Contacts. When two or more pieces of metal are used and the arrangement is such that when they come together a circuit is closed, they are called contacts or contact points.

30. Core. The mass of iron or iron wires forming the interior portion of an electro-magnet or induction coil, and around which wire is wound. The part is caused to be magnetized when current flows through the wire that surrounds it.

31. Direct Current. Current that flows constantly in the same direction.

32. Distillation. An operation in which two or more liquids may be separated by boiling. Distilled water is made by boiling water, catching the steam that arises and cooling it, returning it to pure water.

33. Distributor. A mechanically operated device used to direct the flow of current in a number of different circuits. A distributor used in connection with an ignition system is usually a timer and distributor combined. It is so arranged that it times the flow of current in the primary circuit and distributes the high-tension current to the wires that go to the spark plugs. In many distributors the same contact points used in closing the primary circuit acts as an interrupter. (See Interrupters.)

34. Electricity. The name is given to an invisible agent known only by its effect and actions. We know how to control the action of it to a great extent, and no matter how it is produced, we believe it to be one and the same thing.

35. Electric Pressure. The pressure upon the current flowing in a circuit. This pressure is measured in Volts.

36. Electric Resistance. Anything that resists the flow of current. Large wires, low resistance. Small wires, high resistance. This resistance is measured in Ohms.

37. Electro Magnet. If an insulated wire is wound around an iron core and current is passed through the wire, this is an electro-magnet. Sometimes the wire is wound on a spool made of non-magnetic material, and so arranged that the core can be inserted or withdrawn as desired. This form is known as a solenoid magnet.

38. Electrolyte. The solution used in a storage battery. Is generally made by mixing sulphuric acid and distilled water in proportion of two parts of acid and five parts of water. These parts are measured out by volume. An earthen vessel must be used and the solution stirred while mixing. **Never pour the water into the acid.** (See Gravity.)

39. Energy. The power of doing work. Passing a current of electricity through a storage battery causes energy to be stored up in a chemical form. Then this energy is taken off in an electric form. Winding a watch causes energy to be stored up in a mechanical form in the spring.

40. Field. A term applied to a space occupied by electricity or magnetic lines of force.

41. Flow of Current. Flow of current is measured in Amperes. Current flows under a certain number of volts pressure.

42. Field Coil. The coil of insulated wire which surrounds the pole pieces of a motor or generator.

43. Foot Pound. This is a unit of work or energy. The lifting of one pound one foot.

44. Generator. A machine which converts mechanical energy into electric energy.

45. Gravity. Referring to the electrolyte used in a storage battery, the gravity depends upon the proportions of water and acid. The gravity of water is 1.000, and that of chemically pure sulphuric acid is 1.840.

46. Grooving Out Micas. The separators or insulators between the segments of a

commutator are made of mica. In the wear of a commutator the copper will wear faster than the mica, and it becomes necessary to groove the micas out so they will be below the surface of the copper. This is done with a file and hack-saw blade. Full information on this subject will be found under "Care of the Motor and Generator."

47. **Ground.** The frame of the car is known as ground.

48. **Ground Wire.** Used to connect a piece of apparatus to the frame of the car.

49. **High Tension.** This term applies to High Voltage.

50. **High Tension Magneto.** A magneto in which the means of increasing pressure (voltage) is incorporated within the machine.

51. **High Tension Wire.** Wire with a very heavy insulation of rubber or other good insulating material.

52. **Horsepower.** The power required to lift one pound 550 feet in one second.

53. **Hydrometer.** Used to test the gravity of solution in a storage battery. A floating device with a scale inside of a glass tube.

54. **Ignition Coil.** An induction coil used in connection with ignition systems to assist in increasing voltage.

55. **Induced Current.** Interrupting the flow of current in the primary circuit of an ignition system causes current to be generated into the secondary winding of the ignition coil. This is called induced current.

56. **Insulation.** Covering used on wires as an insulator. A material that is a non-conductor.

57. **Interrupter.** A device used to interrupt the flow of current in the primary circuit for an ignition system. This is necessary in order that current be generated into the secondary winding of the ignition coil or armature. The armature of a high tension magneto has both primary and secondary winding on it. In some battery systems a vibrator is employed as an interrupter, and in others a relay is used. In some systems, by a mechanical means, the circuit is closed and opened.

58. **Kilowatt.** 1,000 Watts. A unit of electric power. Electric power is generally expressed in Kilowatts. The watt is the 1/746 of a horsepower. The kilowatt is equal to about one and one-third horsepower.

59. **Lines of Force.** If an insulated wire is wound around an iron core and current is passed through the wire, it causes the iron core to become magnetized and lines of force pass between the poles of the magnet. This is from one end of the iron core through the air to the other end.

60. **Line Resistance.** Resistance of the wire used in completing a circuit.

61. **Low Tension.** This term is used to indicate low voltage.

62. **Low Tension Magneto.** A magneto that has in connection with it a separate ignition coil.

63. **Low Tension Wire.** Wires used to carry currents of a low pressure (voltage). Insulation on this wire is thin, compared to that of the high-tension wire.

64. **Magnet.** A body possessing the power of attracting metals of a similar character to it. A body possessing a magnetic field.

65. **Magnetic Attraction.** The attraction exerted by opposite poles upon each other.

66. **Magnetic Field.** The region surrounding a magnet, through which lines of magnetic force act. The magnetic field is said to be comprised of lines of magnetic force.

67. **Magnetic Repulsion.** The repulsion exerted by like poles against each other.

68. **Magnetism.** The peculiar properties possessed by certain substances, such as iron or steel, in virtue of which they exert force of attraction or repulsion.

69. **Magnetize.** To communicate magnetism to a substance. To become magnetic.

70. **Magneto.** An alternating current generator used to produce a spark in the cylinders of a gas engine.

71. Molecule. Iron or steel is said to be made up of molecules. They may be considered as little magnets.

72. Motor. A machine used to convert electric energy into mechanical energy.

73. Motor Generator. A machine that may be used as a motor or generator.

74. Negative. A term used to indicate the direction of flow of current returning to the source.

75. North Pole. A name given to one of the poles of a magnet.

76. Ohm. The unit of electric resistance. Resistance to the flow of current is measured in Ohms.

77. Ohms Law. Volts divided by Amperes equal Ohms. Volts divided by Ohms equal Amperes. Amperes multiplied by Ohms equal Volts. If any two terms are known, the third can easily be found by this rule.

78. Open Circuit. A circuit the electrical continuity of which has been interrupted. A broken circuit.

79. Open Condenser. A condenser in which the tinfoil has been separated or broken away from the terminals.

80. Overcharge. Passing current through a storage battery after all of the acid has been forced out of the plates.

81. Paints. Thick liquids used to give colors to objects or to preserve them. Most paints are conductors of a current of electricity, and much care must be exercised in their use around the insulations of any electric system.

82. Permanent Magnet. A magnet made of hardened steel that possesses magnetic powers.

83. Polarity. The possession of magnetic poles. Also in testing the wires of a charging circuit for polarity to ascertain the direction of flow of current, this term is used. In making this test, fill a glass with water and stir in it some salt. Then dip the ends of the wires in the solution. If it is direct current, bubbles will come off the negative wire. If it is alternating current, bubbles will come off both wires.

84. Pole (Magnetic). One of the ends of a magnet.

85. Pole Piece. In motors or generators, the part that is surrounded by a field coil is called the pole piece.

86. Positive. A term used to indicate direction of flow of current from the source.

87. Power. The rate at which work is done. Mechanical power is generally measured in horsepower, which is equal to the lifting of 550 pounds one foot in one second.

88. Primary Circuit. One of the circuits where the wires are larger than others in the same system, and through which low-pressure current flows.

89. Rectifier. An electric instrument used to change alternating current into direct current. One of these instruments must be used when only alternating current is available for charging batteries.

90. Relay. An Electro-magnet used to open or close a circuit.

91. Relay (Ignition). Used as an interrupter in connection with a battery ignition system.

92. Relay (cut out). Used to open or close a circuit, depending upon the pressure of the current flowing through one or more of its windings.

93. Relay (Current regulating). Used to control or regulate amount of current generated by generator.

94. Residual Magnetism. The magnetism retained in the core of an electro-magnet after current ceases to flow through the coil.

95. Resistance. That which a substance offers to the flow of an electric current.

96. Resistance Wire. A wire composed of some special alloy, and used in a circuit to offer resistance to the flow of current.

97. Return Circuit. The portion of an electric circuit through which the current is returning to the source or starting point.

98. Rheostat. A variable resistance box used to regulate the flow of current in a circuit.

99. Secondary Winding. The secondary winding of a coil is the smaller wire used where two different sizes of wire are employed.

100. Segments. The copper bars of a commutator as used on the armature of a motor or generator.

101. Series. This term as applied to the winding of field coils means that the circuit through the machine is so arranged that the current that flows through the series field flows through the armature windings. When a number of pieces of electric apparatus are connected in a circuit so as to let the same current flow through each piece, these parts are said to be connected in series.

102. Series Field Coils. Field coils connected in series with the armature. The same current that flows through the coils must flow through the armature when operated as a motor.

103. Shellac. Shellac dissolved in alcohol forms shellac varnish, and is a good insulator to use in electric systems or their insulations. If the ends of cotton-covered wires are shellaced it will prevent raveling of the insulation.

104. Short Circuit. When an electric connection is made that gives the current a shorter path to flow through to return to the source than that of the original circuit, that is said to be a short circuit.

105. Shunt Field Coils. Field coils that are connected across the brushes of a machine in such a way that a part of the current that flows through this machine (if operated as a motor) flows through the armature and a part through the coils.

106. South Pole. This term is applied to one of the poles of a magnet.

107. Volt. The unit of measurement of electric pressure.

108. Watt. The unit of measurement of electric power.

SWITCHES

1. Construction. A switch in its simplest form is nothing more than a means of opening and closing an electric circuit.

2. When a switch is closed, current can flow. When a switch is open current cannot flow through it. When a switch is closed it is said to be "on." When open, it is said to be "off."

3. The most important parts of a switch are the contacts, insulation, operating mechanism, and frame or grounding.

4. Switches may be either hand operated or may be automatic in operation. We shall deal only with the hand operated switch in this work.

5. Contacts. The purpose of the contacts is to make it easy to open and close the circuit with the least possible amount of burning or arcing in the point of break.

6. When current is flowing in a circuit we interrupt the flow by opening the circuit, and current always tends to keep on flowing across the gap at the point of interruption. Switch contacts, therefore, are very liable to burn or corrode, due to this cause.

7. Excessive burning of contact points is generally due to the amperage being too high, contacts too small to carry the necessary current, poor contacts, or poor contact material.

8. Amperage too high. This is usually due to a short-circuit, cutting out some piece of apparatus and allowing a heavy flow of current through the switch.

9. Broken contacts. Poor contact is generally due to dirt or corrosion. Contacts not coming properly together or bent contacts, not making firm contact to the spring tension, or pieces of insulation getting in between the contacts.

10. Switch contacts are very often made of copper, because this material is an excellent conductor and does not oxidize.

11. Insulation. Insulation is necessary to prevent current from getting through the switch at any other place except the contacts, when closed. Various materials are used for insulation, which are hard rubber, fiber, and bake-lite.

12. Switches are of various types, usually determined by the method of operating. The most commonly-used switches are known as knife switches, push-button switches, lever, and rotary switches.

13. The lever or rotary switch is most commonly used on automobiles. Therefore we will confine the instruction to this switch only.

14. In switches of the lever or rotary type a conductor or contact arm is rotated about its center. In one position it makes contact with two face contact points, which are mounted in an insulated base. In another position the contact arm is moving away from the contact points and rests on the insulation.

15. Frame or Mounting. The frame of the switch may be either of metal or some insulated material, such as hard rubber or bake-lite. If made of metal all contact and terminal posts must be carefully insulated to prevent grounds and short circuits.

16. Inspection and Care of Switches. The important parts of a switch to inspect are the contact points, contact arms, contact springs, and the insulation.

17. Contact Points. These must be clean and properly fitted so as to make perfect contact, otherwise burning and pitting will take place. Loose or broken contact points should be repaired or replaced when found in this condition.

18. Contact Arms. This same thing applies to contact arms. See that they are not bent or cracked.

19. Contact Springs. These must be inspected to see that they have the proper amount of tension so as to hold the contacts firmly together. They must not be too strong, however, because this will cause excessive wear of the contacts.

20. Insulation. See that all contact points, arms, connectors, and terminal posts are properly insulated. Examine all insulation to see that it is not cracked, broken, or missing. Always replace broken insulation when found in this condition.

QUESTIONS

1. What is a switch?
2. Give terms used in reference to switch lever positions.
3. What are the most important parts?
4. How are switches operated?
5. What is the purpose of the contacts?
6. What results when a switch is opened?
7. Give most common cause for the contacts burning.
9. Give cause of poor contact.
10. Why are contacts often made of copper?
12. Name some of the most commonly-used switches
13. What kind is used on automobiles?
14. Describe operation of rotary type switch.
15. If switch frame is made of metal, what must be done?
16. Name most important parts to inspect.
17. Give proper condition of contact points.
18. Give proper condition of contact arms.
19. Give proper condition of contact springs
20. Give method of inspecting insulation.

IGNITION

1. Ignition. By ignition we mean the act of igniting or setting fire to the mixture of gas and air in each cylinder of a gas engine, at the proper time.

2. If we connect two wires to a battery, one to the positive terminal and one to the negative terminal, as long as the two ends of the wires are held apart nothing happens. If we bring the two ends of the wires together, the current immediately begins to flow through the circuit just completed.

3. When we separate the wires, the current tends to keep on flowing in the same direction and just at the instant of separation of the wires it will jump the gap thus produced.

In doing so, it has to break down the insulation between the ends of the wire, namely the air, and a spark takes place.

4. This is the simplest way of obtaining a spark, but it will be noticed that the spark thus obtained is very weak and the ends of the wires have to be very close together before the spark will jump. In what is called the primary ignition circuit an action similar to the above takes place.

5. The point of interruption is known as the breaker points or contact points. It is not possible, however, to obtain a sufficiently strong spark by means of the primary circuit alone. In other words, it is not practical to increase the voltage of the primary circuit to such an extent as to obtain ignition directly from it.

6. Instead of this, a method is used in which we have a secondary current otherwise known as "high tension." This is produced by means of an ignition coil and in this way we obtain the spark that actually fires the charge or mixture in the cylinders.

7. Ignition Coil. This brings us to the Ignition Coil, which is also known by various other names, such as induction coil, spark coil, etc.

The laws governing the operation of an ignition coil are well understood and coils can be satisfactorily designed and constructed to perform any desired duty.

8. We know that if certain conditions are fulfilled in constructing a coil and operating it, certain results will be obtained. If the proper results are not obtained, it is because one or more of the necessary conditions are not being fulfilled.

9. A Battery Ignition System consists of two circuits, a Primary or Low Tension circuit and a Secondary or High Tension circuit.

The following parts are necessary: Source of current, which may be either **Dry Cells, Storage Battery,** or a **Generator** (low voltage). **Contacts** or **Breaker Points,** used to make and "break" the primary circuit; time the instant at which the "Break" takes place. **Ignition Coil,** with two windings, known as **Primary** and **Secondary.**

10. Condenser. Its function in the primary circuit is to prevent arcing at the contact points (also used in secondary circuit to "step up" the voltage).

Switch. To open or close primary circuit when required.

Wiring necessary to connect up the various parts just mentioned. The construction of an ignition coil is very easy to understand.

11. The following parts are used in the construction of an Ignition Coil:

Core. End irons, Primary winding, Secondary winding, Insulating material, Housing and Terminals.

12. The core consists of a number of short lengths of soft iron wire perfectly straight. These wires are formed into a round bundle and several layers of good insulating material (such as specially prepared paper, linen, or silk) are then wrapped around the bundle.

13. The end irons are two circular iron plates. They are placed one at each end of the core and held firmly in place so as to make good contact with the core. The core and end irons thus form a spool.

14. A number of turns of heavy copper wire (insulated wire) are then wound on the core, forming the primary winding. This primary winding forms part of the Primary or Low

Tension Ignition Circuit. Several layers of good insulating material are then wrapped around the primary winding.

15. Secondary Winding. A very large number of turns of fine copper wire (insulated wire) are then wound on top of the primary, each layer of winding being separately insulated from the layers next to it. The purpose of this extra insulation in the secondary winding is to prevent a "break-down" between the layers of winding.

16. If only one or two adjacent turns of the secondary winding were short circuited or "broken down," it would make very little difference in the action of the coil. If two or more layers, however, were short circuited, the results would be serious. The insulation between the layers extends out beyond the ends of the winding so as to prevent any possibility of short circuiting at the ends.

17. Insulating Material. As will be seen later, the action of the coil is to produce a current of very high voltage in the secondary winding. It is necessary, therefore, that Ignition Coils be carefully built and thoroughly insulated at the places mentioned above.

18. Housing and Terminals. After the windings and insulation are in place, the coil is usually mounted in a Housing to protect it from moisture and other kinds of injury.

The terminal ends of the windings that are to be connected in the circuit are led to Terminal Posts mounted on the Housing.

19. Condenser. The construction of a condenser is very simple. Essentially a condenser consists of two pieces of tin-foil which are completely insulated from each other. The insulation usually consists of two layers of thin paraffin paper.

20. In one form of construction the tin-foil is made in long narrow strips. The two strips of tin-foil are then placed with two layers of paraffin paper in between, and two more layers of paper, one on the outside of each strip of tin-foil.

21. The whole is then rolled up into the desired shape, circular, rectangular, etc. Each strip of tin-foil is, therefore, entirely insulated from the other, and each is connected to a terminal by means of which the condenser may be connected in the circuit.

QUESTIONS

1. What is meant by Ignition?
2. What results when a circuit is completed?
3. What results when a circuit is opened?
4. Why is the spark weak in pressure?
5. Give name applied to point of interruption.
6. How is a strong (high voltage) spark produced?
7. Give other names applied to "Ignition Coil."
8. What may be said of ignition coils?
9. How many circuits in a battery ignition system? Name parts necessary.
10. What is the condenser for? Purpose of switch?
11. Name parts used in construction of an ignition coil.
12. What is the core composed of?
13. Where are the end irons placed?
14. Give name of the windings of an ignition coil.
15. Give reason for insulation between layers of secondary.
16. If two or more layers of the secondary were short circuited, what would result?
17. Why is it necessary to be so careful with the insulations?
18. Why is a coil placed in a housing?
19. What is a condenser composed of?
20. Give one form of construction.
21. Why are terminals used?

22. Operation of Coil and Condenser. When the ignition switch is closed, current does not immediately flow from the Storage Battery through the primary circuit, unless the

distributor contact points are closed. Just as soon as the contact points come together, due to the engine being turned over, current flows from the battery through the ignition primary circuit, which includes the primary winding of the ignition coil.

23. The points, however, are closed only for a short period and almost immediately opened again, due to the action of the distributor cam.

Two things that are to be noted here are:

Closing the primary circuit, opening the primary circuit.

24. Closing the Primary Circuit. When the circuit is closed, current flows through the primary winding of the ignition coil. This causes the core to become magnetized. The lines of force, therefore, flow through the core and end irons, completing the magnetic circuit through the air.

25. Opening the Primary Circuit. When the circuit is opened at the contact points, the lines of force tend to "die out" in the core. This has the effect of making a current of electricity flow through the secondary winding of the coil.

26. If the interruption of the primary current is made suddenly, a high voltage will be obtained in the secondary windings. In other words, the more quickly the lines of force are made to die out in the core, the higher the voltage obtained in the secondary.

27. Operation of Condenser. The operation of the condenser may be described as follows: When the primary points open, current tends to keep on flowing across the gap. This causes arcing at the Points, which eventually would cause them to pit or burn.

28. The condenser is connected across the primary points and does two very important things, which are: Reduces the arcing at the primary points, and increases greatly the voltage in the secondary winding.

The condenser may be said to absorb the current that otherwise tends to flow across the primary points at the instant they "break."

29. The increase of voltage in the secondary is due to the fact that the condenser does not retain the current absorbed, but immediately discharges it. The condenser discharge, however, causes the primary current to flow in the opposite direction to that in which it was originally flowing.

30. It has already been said that a current having a high voltage is induced or caused to flow in the secondary winding of the coil at the instant the primary circuit is interrupted. Also that if the primary be interrupted very rapidly the voltage of the secondary current will be much greater.

31. The sudden discharge from the condenser, therefore, in the opposite direction to the original flow of the current in the primary winding has the effect of interrupting the flow of current very suddenly. In this way the high voltage necessary for ignition is obtained in the secondary circuit.

32. Spark Plug. The spark plug is simply a means of making a gap in the secondary circuit, which can be placed inside the firing chamber of the gas engine. The high voltage induced in the secondary winding causes arcing to take place at the spark plug points. The contact points in the distributor are timed to break just at the instant when the spark is required in the cylinder.

33. Note. It is usual to "ground" one end of the secondary winding to the coil bracket, which in turn is connected to the frame of the engine. The other end of the secondary leads to the distributor, from which it goes in turn to the center point of each spark plug.

34. The center point of the spark plug is insulated from the engine frame. The other point of the spark plug is attached to the body of the plug, which is screwed into the cylinder head. The secondary circuit is, therefore, completed through the frame of the engine.

QUESTIONS

22. Does current flow immediately when the switch is closed?
23. What causes the interrupter points to open and close?
24. When does current flow through the primary? What effect has the flow of current?
25. What results when the contacts open?
26. What is necessary to generate high voltage?
27. If it were not for the condenser, what would result when the primary points opened?
28. How is the condenser connected?
29. Describe the increase of voltage in the secondary.
30. How does current get into the secondary of the coil?
31. Give effect of condenser discharge.
32. What is a spark plug?
33. To what are the ends of the secondary connected?
34. Describe the secondary circuit.

DISTRIBUTORS

35. The term "distributor" properly means the part of the ignition system used to distribute the high tension current to the spark plugs. For the present purpose, however, we will include also the breaker mechanism used in the low tension circuit of the ignition system.

36. The reason for this is because the breaker mechanism and high tension distributor are often built together and form a single unit.

The breaker mechanism will be described under the following heads: Purpose of Breaker Mechanism, Construction of Breaker Mechanism, and Care and Adjustment of Contact Points.

37. Purpose of Breaker Mechanism. A cam, known as the distributor cam, containing the necessary number of points or "lobes" is driven by means of gears from the crank shaft of the engine. The number of points on the cam is determined by the number of cylinders to be fired.

38. Sometimes one cam is used for all the cylinders in the engine, and sometimes two cams are used. If only one cam is used there will be as many points on the cam as there are cylinders. A four-cylinder engine thus having a 4-point cam, etc.

39. If two cams are used there will be two separate distributors. Each distributor will, therefore, be used for half the number of cylinders and the timing will be arranged so that the distributors work alternately.

40. When two distributors are used in the above manner, there will be only half as many points on each cam as there are cylinders. This arrangement would of course only be used on engines having a large number of cylinders and running at high speed. A 12-cylinder engine, for example, might have two distributors, each distributor having a 6-point cam and timed so as to work alternately.

41. On any four-cycle engines the speed of the ignition cam must be exactly half the speed of the crank shaft. The reason for this is because each cylinder in a four-cycle engine only fires once during two revolutions of the crank shaft.

42. The distributor cam operates or alternately opens and closes a pair of contact points. These contact points form part of the low tension or primary circuit.

43. When the contact points are closed (after the ignition switch is closed) current can flow through the primary circuit.

When the contact points are opened, by the action of the cam, the flow of current through the primary circuit is interrupted at this point and no more current flows until the points close again.

44. Care and Adjustment of Contact Points. The contact points are made of a material that must possess the following properties:

Low resistance to the flow of current, hardness, and not readily oxidized.

45. Platinum is often used for ignition contact points, particularly on magnetos. Tungsten, however, is found to be more suitable for contact points used on battery ignition. Tungsten is an extremely hard metal and cannot be filed. When Tungsten points require to be redressed or re-faced, an oil stone or sand paper should be used.

Contact points should come squarely and evenly together.

46. When the points become pitted, it will be noticed that one point has a small hollow burned in it while the other point has a small point projecting from it. To re-face these points it is only necessary to rub down the projecting point with the oil stone or sand paper.

47. The point containing the hollow does not need to be faced. Care must be taken not to round off the face. It must be made perfectly flat and must fit squarely against the other point.

48. Contact points must be kept clean, because oil or dirt will cause excessive arcing across the points. This causes them to pit rapidly. The adjustment of the gap or distance between the points is very important.

49. Points should be set to the gap recommended by the manufacturers. This may vary considerably, depending upon the type of apparatus used, so it is always best to know the correct setting for each type.

QUESTIONS

35. What is a distributor?
36. Why is the breaker mechanism usually built in with the distributor?
37. How is the cam driven?
38. How many lobes on the cam?
39. How many lobes on the cams when two are used?
41. Give speed of the cam.
42. What is the operation of the cam?
43. What results when contacts open and close?
44. What kind of material must be used in the contacts?
45. Name two of the best contact materials.
46. Describe condition of points when pitted.
47. Give method of re-facing contacts.
48. What effect will oil or dirt have on the contacts?
49. Is the setting of all contact points the same?

50. Distribution of High Tension Current. Source of High Tension Current. When the contact points in the primary ignition circuit open or "break," a current is said to be induced in the secondary winding of the ignition coil. This induced current is called the High Tension current.

53. The Rotor. The Rotor is simply a revolving arm driven by the distributor cam shaft. The rotor is made of insulating material, but has a metal conductor connecting the center of the rotor with a brush placed at the end of the arm. The wire leading from the secondary winding of the coil makes contact with the end of the conductor at the center of the rotor.

54. High tension current is thus conducted to the brush at the end of the Rotor arm. When the rotor revolves the brush makes contact with a number of brass inserts set in the distributor head. Each of these inserts is connected by means of a wire to the center terminal or electrode of one of the engine spark plugs.

55. The center terminal of the spark plug is entirely insulated from everything else by means of porcelain or some other suitable insulating material.

56. The outer terminal of electrode of the spark plug is attached to the steel part which screws into the cylinder head. In other words, the outer terminal of the spark plug is "grounded" to the engine, when the plug is screwed into place. The High Tension circuit is therefore completed through the frame to the end of the secondary winding, which is "grounded" as already explained.

57. The relation between the rotor brush and the inserts in the distributor head is such that the brush is making contact with an insert each time the breaker contact points separate. Also the breaker contact points are timed to open at the correct instant for firing the cylinders properly.

58. In this way the High Tension current is induced in the secondary winding of the coil at the proper time and the spark jumps the gap in the spark plug and fires the mixture.

59. When removing High Tension wires from a distributor and re-attaching them care must be taken to mark them so as to get them back where they belong. Otherwise the firing order will be changed, and the engine will not run properly.

60. High Tension wires should have specially heavy insulation and should not be allowed to become soaked with oil. This ruins the insulation very quickly and causes short circuits which in turn cause the engine to miss.

QUESTIONS

50. What is meant by "High Tension"?
53. What is a rotor made of?
54. Give operation of the rotor.
55. Is the center terminal of the spark plug insulated?
56. To what is the outer terminal of a spark plug connected?
57. Give relation between rotor brush and inserts in distributor head.
58. What results when sparks jump the gap in the plug?
59. What should be done when removing high tension wires?
60. What effect will oil have on high tension wires?

SPARK PLUGS

61. A spark plug consists of an outer shell, insulating core, center electrode, and outer electrode.

62. Outer Shell. The outer shell is made of steel and is threaded so it can be screwed into the cylinder.

63. Insulating Core. An insulating core or sleeve is used between the outer shell and the center electrode. This is usually made of porcelain, although mica is also frequently used. Porcelain has a tendency to crack due to rapid changes in temperature or to careless handling. Mica tends to become oil soaked through time.

64. Center Electrode. The binding post or spark plug terminal connects to the center electrode or "point." Electrodes are usually made of Platinum, Iridium, and Nickel Alloys.

65. Outer Electrode. This is attached to the outer shell and enables the High Tension current to "ground" after jumping the gap between the points. The distance between the points is very important and must be carefully adjusted by means of a gauge. The gap will vary with different types of ignition, therefore it is absolutely necessary to know the correct size of gauge to use.

66. Do not depend on your memory, but find out what is the correct gap for the system you are working with and set the spark plug points accordingly.

67. If the points are too far apart the resistance to the flow of current across the gap is increased. In other words, it makes it more difficult for the current to jump the gap. A small amount of dirt or oil on the surface of the insulation will, therefore, provide an easier path for the current and the plug will then be short-circuited.

68. Examining Plugs. When a spark plug is removed for examination, first clean it thoroughly, using gasoline. Then inspect carefully for broken insulation, cracked insulation, and condition of points.

69. Broken Insulation. This can usually be readily seen, but in some cases the break may be invisible until the plug is taken apart. Always shake the plug and listen for a rattle indicating broken porcelain.

70. Cracked Insulation. This is often difficult to detect, unless it is by noting that the points are not burned white, or the cylinder misses at high speed. If any plug fails to show a whitish appearance on the points, the insulation is probably defective, and the plug should be replaced with a new one.

71. Condition of Points. When a plug is firing properly the points should show the whitish appearance mentioned above. Sometimes small metallic beads will be found on the points. This indicates that the points are set too close, and should be adjusted 002″ or 003″ farther apart.

72. Care of Spark Plugs. When it is necessary to scrape carbon from the plug, this should be done very gently. Be careful not to wedge anything between the shell of the plug and the insulation, because this might crack the insulation. Always use a gauge of the proper thickness to adjust the points.

73. Use New Spark Plug Gaskets frequently. After being used a few times the gaskets become flattened and it then becomes necessary to put a great strain on the wrench in order to make the plugs tight. This usually results in a broken porcelain. Never drop spark plugs or handle them roughly because there is a danger of cracking the porcelain.

74. If a few drops of oil are placed on the spark plug thread before screwing it into the cylinder, it will be much easier to remove.

QUESTIONS

61. Name the parts of a spark plug.
62. Give construction of the outer shell.
63. What kind of insulating materials are used?
64. What are electrodes made of?
65. To what is the outer electrode connected?
66. Should the spark plug gap always be the same?
67. What will result if the gap is too wide?
    What effect will oil or dirt have on the operation of a plug?
68. Give method of inspecting a spark plug.
69. Give method of inspecting for broken insulation.
70. What would indicate cracked insulation?
71. What indicates that the plug is firing properly?
72. Give general care of plugs.
73. Why replace spark plug gaskets?
74. Why use oil on the threads of a spark plug?

IGNITION THEORY.

The seventeen figures on pages 42 and 43 are intended to make clear the operation of an induction coil and battery ignition systems.

In Figure 1 we have a soft iron core, showing the molecules in their original state, which are in confused positions.

In Figure 2 is shown the same soft iron core and the positions the molecules would assume if this iron core was magnetized. You will note in Figure 2 that the molecules are all parallel with each other. We have omitted showing the lines of force that would pass from pole to pole of this magnet through the air.

In Figure 3 is shown an arrow, which represents the position of a molecule in a bar of soft iron. Note its position.

In Figure 4 we have the same bar of soft iron with an insulated wire wrapped around it and a current of electricity from one dry cell passing through this wire. The effect of the electricity passing through the insulated wire which is wound around this iron core, has caused the molecule to change its position as indicated by the arrow. Note that one end of this bar is marked "N" indicating North Pole, and the other end marked "S," indicating South Pole.

In Figure 5 we have the same bar of iron, the only difference being that current is passing through the wire which surrounds this core in the opposite direction. The arrow indicates the position of the molecules under this condition, which shows that the polarity of this magnet has reversed, making one end the North Pole and the other end the South Pole just opposite to Figure 4.

The polarity of an electro magnet depends then upon the direction the insulated wire is wound around the core and direction current flows through this wire.

In Figure 6 lines of force are shown in their direction of travel. Note that the lines of force pass through the air from the North to the South Pole and through the metal from the South to the North Pole.

In the construction of an ignition coil it is necessary to produce as many lines of force as possible from a small amount of metal. The efficiency of an induction coil with a solid iron core would be very low, due to the fact that eddy current would interfere greatly.

In Figure 6 is shown the direction lines of force travel in the solid iron core and through the air. While in Figure 7, which is an end view of the same piece of metal, the direction of travel of eddy currents is shown. Note the whirl of these currents. These eddy currents as shown in Figure 7 have a tendency to decrease or interfere with the travel of lines of force as shown in Figure 6.

Therefore, it is not advisable to use a solid iron core in an induction coil. Instead we use soft iron wires, as shown in Figure 8. The soft iron wires as shown in Figure 8 have been annealed, which make them soft, also a scale has been formed on them. These wires are formed into a bundle with an insulation surrounding them, and then several turns of very heavy wire are wrapped around this core as shown in Figure 9.

This winding is known as the primary. An insulaton is now placed over the primary winding, and upon this is wound what is known as the secondary as shown in Figure 10. This wire is wound on in layers with two sheets of parafin paper between each layer.

In Figure 11 is shown a complete induction coil that has been sawed in two in the middle, which shows very plainly the positions of the core and the windings. At "A" is shown the secondary, often called "High Tension" Winding. At "B" is shown the primary or coarse winding. At "C" is shown the soft iron wire core. In the operation of an induction coil it is first necessary to pass a current of electricity through the primary or coarse winding, which creates lines of force, which travel through the air and the core as indicated in Figure 12.

When the flow of current in the primary circuit is interrupted, the core of the induction coil quickly becomes demagnetized, as shown in Figure 13. When the core becomes demagnetized almost instantly as it does in the operation of an ignition coil, you will note the position assumed by the molecules. Also the lines of force that were traveling through the air. Instead of continuing to travel through the air in order to return to the core, they are taking the shortest path which is directly through the space occupied by the secondary or high tension winding, as shown at "A."

In the operation of a generator, lines of force are first created and then a coil of wire is revolved through them. In the operation of an ignition coil lines of force are first created and then caused to travel through the secondary winding of this coil, as shown in Figure 13.

Figures 14, 15, 16, and 17 are intended to make clear the difference between a vibrating coil ignition system and a single spark ignition system.

In Figure 14 is shown a skeleton or circuit diagram of an ordinary door bell, connected in series with a six volt storage battery and a push button. "A" represents the bell; "B" the tapper, which strikes the bell; "C" is a stop for the armature to rest against; "X" is the contacts where the circuit is opened and closed, when armature vibrates; "F" is the armature; "G" is the tension spring on the armature;

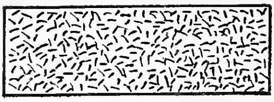


FIG. 1

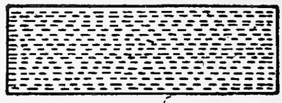


FIG. 2

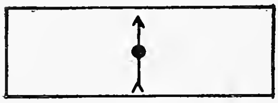


FIG. 3

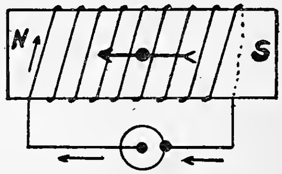


FIG. 4

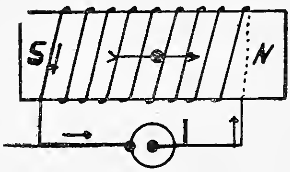


FIG. 5

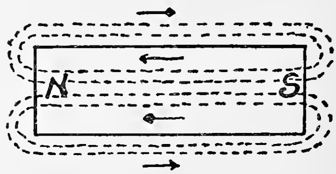


FIG. 6

FIG. 7

FIG. 8

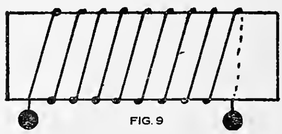


FIG. 9

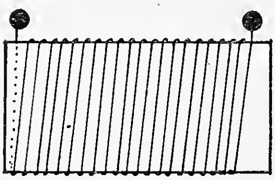


FIG. 10

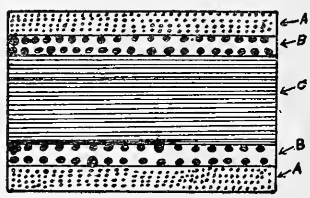


FIG. 11

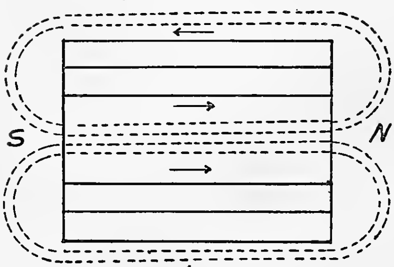


FIG. 12

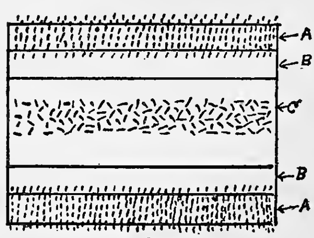


FIG. 13

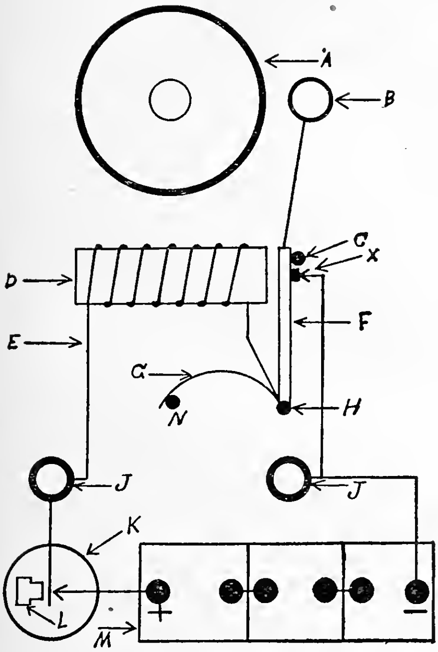


FIG. 14

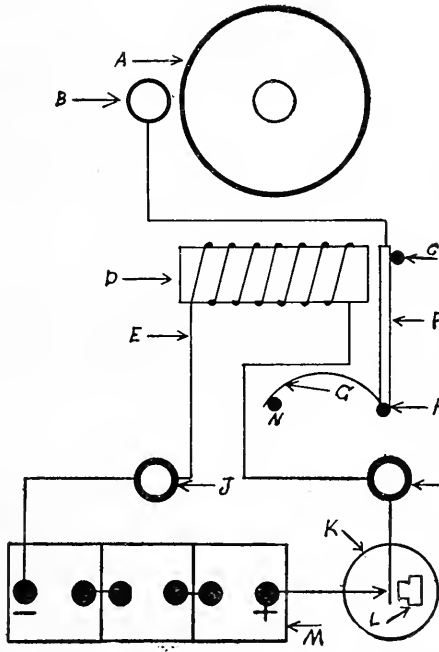


FIG. 15

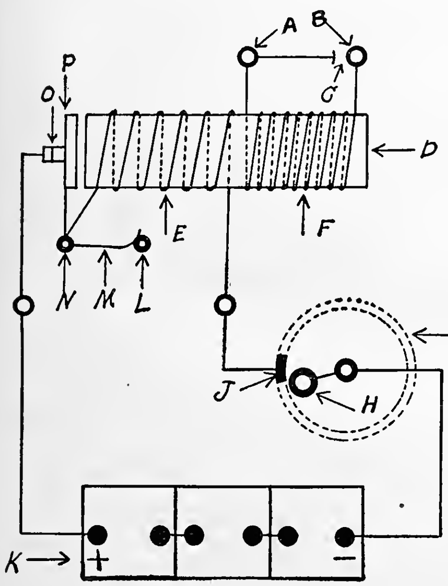


FIG. 16

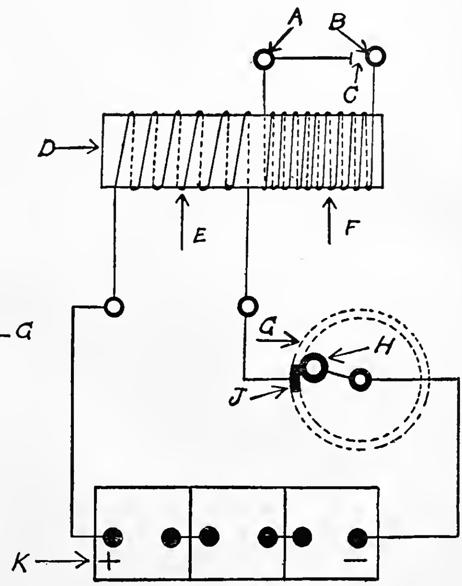


FIG. 17

"H" is the hinge joint of the armature; "D" is the iron core upon which winding "E" is wound; at "J" is shown the terminals of the bell itself; "K" is the push button, and "L" is the small button that is depressed when bell is operated. "M" is the six-volt storage battery.

When the small button "L" is depressed, a circuit is completed. This in turn permits current to flow from the storage battery through the winding which surrounds the iron core. The core almost instantly becomes magnetized and attracts armature "F" which causes tapper "B" to strike the bell. At the instant of this operation, you will note that the contacts separate at "X," which opens the circuit. The core then demagnetizes and releases armature "F" which falls back to its original position.

When armature "F" falls back to its original position it closes the circuit again, and the same operation will take place again as just described. In fact, just so long as the small button "L" is depressed, armature "F" will vibrate back and forth and tapper "B" will continue striking the bell. This gives us a great number of strokes for each depression of the button. The same thing occurs in an ignition system, when a vibrator is used on a coil.

In Figure 16 is shown a vibrating ignition coil connected in series with a timer, and a six-volt storage battery. "A" and "B" are the terminals of the secondary winding of the coil. This winding is shown on one end of the core in order that we may make clear the two circuits. "C" is the space between "A" and "B" at which high tension current generated into the secondary will jump. This space is called a gap. "D" is the core of the induction coil. "F" is the secondary winding. "E" is the primary winding. "L" is the spring stop. "M" is a tension spring, used to hold the armature in its proper position when not operating. "N" is a hinged joint of the armature. "O" is the contacts, and "P" is the armature. At "J" is shown the contact in the timer, and "H" is the roller which travels in the timer and makes contact once for each revolution. "G" shows the timer. The dotted lines represent the insulated portion of the timer. At "K" is shown the six-volt storage battery.

The instant contact is made in the timer, armature "P" will start vibrating just the same as armature "F" in Figure 14 will vibrate when button is depressed.

After the armature "P" in Figure 16 is attracted towards the core, current is generated into the secondary winding of the induction coil and jumps the gap at "C." Armature "P" will continue vibrating just as long as roller "H" is in contact with contact "J." This means that a great number of sparks will occur at "C." The vibrator of the bell is identically the same as the vibrator of the ignition coil, and in either case will vibrate rapidly just so long as the circuit is completed.

In Figure 15 is shown a single stroke bell. When the small button at "L" is depressed, current will flow from the storage battery through the winding, which surrounds the iron core "D." This will cause the core to become magnetized, which will attract armature "F." This armature will be attracted and remain over against core "D" so long as button is depressed. The instant the button "L" is released, the circuit will be opened which allows the armature "F" to return to its original position. When armature "F" returns to its original position, the tapper "B" will strike the bell one time. In fact, tapper "B" will strike the bell one tap only for each time button is depressed.

In Figure 15 you will note, there is no vibrator in connection with this bell which makes it known as a single stroke bell.

In Figure 17 is shown an ignition system very similar to the one shown in Figure 16, with the exception that the vibrator has been eliminated. In this system we do not get the spark from the secondary winding of the induction coil, when we make contact in the timer. Instead we get a spark from the secondary winding of the induction coil at gap "C" when roller "H" leaves contact "J." When roller "H" makes contact with contact "J" current flows through the primary winding of the ignition coil which causes the core to become magnetized, and will remain in

this condition until roller "H" leaves contact "J." At the instant roller "H" leaves contact "J" current is generated into the secondary winding of the induction coil and a spark is produced at gap "C."

We will suppose that current is traveling through the primary circuit of a battery ignition system. It has caused the core to become magnetized and lines of force are passing through the air from the North to the South Pole in many directions. When the timer contacts separate, the current flowing in the primary circuit attempts to go through the condenser. In making this attempt the condenser is charged, but immediately discharges back through the primary circuit, almost instantly. This instant change in the direction of flow of current in the primary circuit causes the core of the induction coil to become demagnetized much more quickly. In fact, the quicker the core becomes demagnetized, the higher will be the voltage of the current generated into the secondary winding, due to the sudden collapse of the lines of force which must pass through the secondary winding to shorten their path when returning to the core.

THE THEORY OF THE STORAGE BATTERY

1. Probably no other piece of electrical apparatus in common use to-day is so generally misunderstood as the storage battery. The following description will give the reader a clear conception of the elementary principles involved in the operation of the storage battery.

2. In effect the storage battery has the same relation to an electrical system that a standpipe or reservoir has to a water supply system; but note the difference in the **Means** which lead to this **Effect.**

3. Water is stored in the reservoir merely as water. Electricity cannot be stored as electricity. In the storage battery the electricity first produces a chemical effect. This action may then be reversed to produce an electrical current.

4. When a current of electricity flows through a solution of water, in which a small quantity of ordinary table salt has been dissolved, the water of the solution will be broken up or decomposed into its component parts—Oxygen and Hydrogen.

5. Let us suppose that current from two dry cells is caused to flow through two platinum wires, the ends of which are immersed without touching each other in a glass of salt water. (A—Fig. 1.) The current must flow through the solution of salt and water, and in doing so will decompose the water into Hydrogen and Oxygen.

6. Bubbles of Hydrogen gas will rise from the wire through which the current leaves the solution, and Oxygen gas will be liberated at the wire through which the current enters the solution.

7. Now, if we should suddenly disconnect the wires from our dry battery and connect them to a sensitive electric measuring instrument we should find that a current flows through the wires **from the glass of salt water** (B—Fig. 1).

8. Closer investigation will show that the small amount of Oxygen and Hydrogen clinging to the wires in the glass had gone back into solution as water, and in so doing had given back in the form of electric energy part of the energy required to liberate them from the solution.

9. In the simple experiment above outlined we have described the action of an elementary and very inefficient storage battery; but the reader will have noted the ability of the electric current to produce a chemical effect, and the ability of chemical action to cause a flow of electric current.

10. Let us carry our investigation a bit further. We substitute for our solution of salt and water one composed of sulphuric acid and water, and instead of using platinum wires in the solution we immerse strips of lead (A—Fig. 2).

11. When we pass our electric current through one lead strip, thence through the solution and out at the other strip, the water is decomposed as before into its elements, Hydrogen

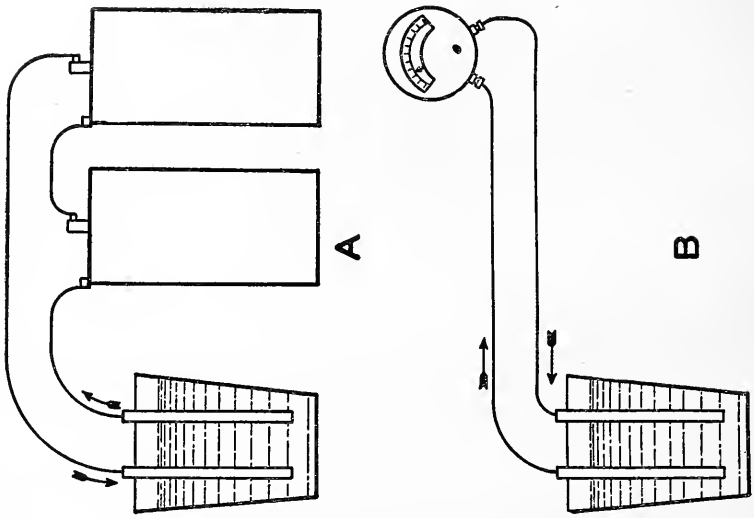


Fig. 2

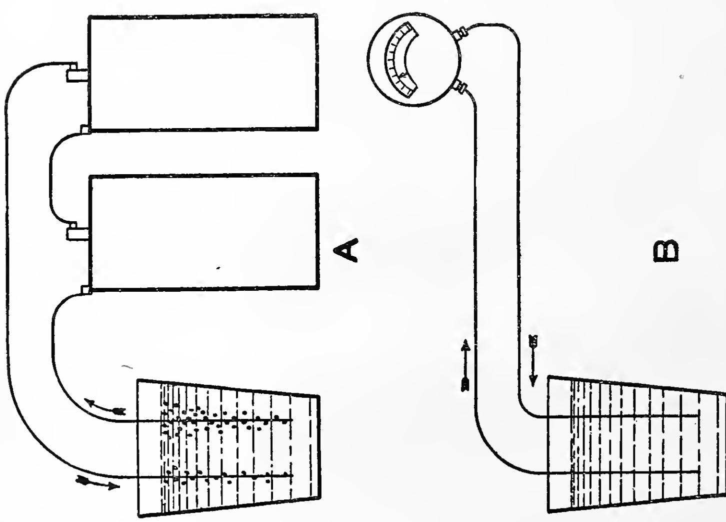


Fig. 1

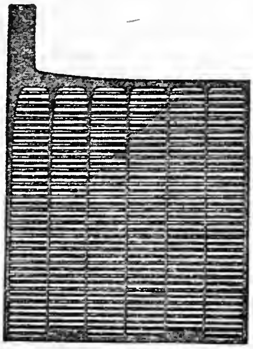


Fig. 3
ALLOY GRID

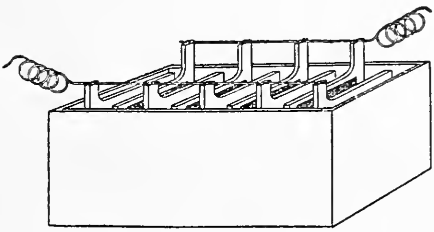


Fig. 4
FORMING TANK

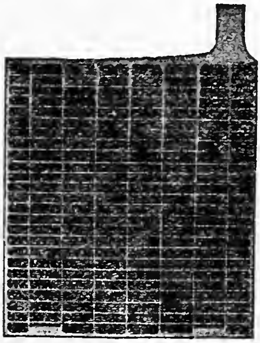


Fig. 5.
FINISHED PLATE.

and Oxygen. However, instead of Oxygen being liberated in the form of gas bubbles at the strip through which the current enters, it combines with the lead strip to form lead oxide, which is a reddish brown color.

12. Now, if we disconnect the source of current and attach our measuring instrument, or voltmeter, to the conductors leading to the apparatus described, we find that an electric current flows for a considerable length of time (B—Fig. 2).

13. The Oxygen which combines with the lead strip to form lead oxide, recombines with the solution, leaving the plate in its original form as metallic lead when the current has altogether ceased to flow.

14. The operation of "charging" or decomposing the solution, or electrolyte, may be repeated, and the complete operation of causing a current of electricity to produce a chemical effect, and then in turn causing chemical action to produce a flow of current, is known as a "cycle."

15. It would be noted in both the experiments described that the current flows in a reverse direction in discharging; that is, if the charging current flows **into** the solution at one strip, it flows **from** the solution at the same strip when discharging.

16. We should further note that no matter how small or how large we made the lead strips, the force of the current discharged from the cell would be about two volts. Our little apparatus contained in a glass tumbler would give rise to the same voltage as the largest storage cell built. However, should we measure the amount of current and the time it flowed from the solution, we would find that these quantities varied with the size of our strips.

17. We have in this second experiment described the operation and essential parts of the ordinary storage battery. While any school boy could construct this simple battery of lead strips and sulphuric acid solution, the design and production of a commercially practicable storage battery involves a tremendous amount of detailed refinement.

18. The storage cell of commercial practicability is made up of the following parts:
A jar, or container, usually made of rubber.
Positive and negative plates.
Separators between the plates.
Solution of electrolyte, and
Covers and Connectors.

19. The plates are made by pasting the active material on a grid of lead alloy (Fig. 3). The grid serves to support this active material, which dries on the grid as a porous mass, exposing a far greater amount of surface to the action of the solution than could be done if a solid strip or plate were used.

20. After the plates are prepared in this manner, they are placed in a lead-lined tank containing a solution of sulphuric acid and water. Current is passed through the plates and solution, as shown by Fig. 4, the current entering through half the number of plates and leaving through the other half.

21. The solution is decomposed, liberating hydrogen at the negative plates (the ones through which the current leaves the solution in charging) and liberating oxygen at the positive plates (through which the current enters the solution in charging).

22. The hydrogen combines with the oxygen of the negative plate, tending to make it pure metallic lead. The oxygen combines with the oxygen already present on the positive plate, changing its form to the brown peroxide of lead described in our second experiment.

23. This initial charging is termed "forming the plates." After they have been formed, the plates are placed together in groups of alternate negatives and positives, held apart by the separators.

24. It has been found in practice that placing two separators between each pair of plates gives the best results. One of these consists of a piece of wood, deeply grooved on one side. The other is a thin, perforated sheet of hard rubber.

25. In assembling, a rubber separator is placed on either side of each positive plate, and a wood separator is placed between each pair of plates, with its grooved side against the negative plate.

27. The group of positive and negative plates is of such dimensions as to practically fill the rubber jar in which it is finally placed, leaving only the pores in the plates, the spaces in the separators, and a small space above and below the plates to be filled with the solution of acid and water.

28. The durability of a storage battery depends first upon the care with which the little details of design and construction are worked out, and after that upon conditions under which the battery is kept in proper condition to perform its functions efficiently.

29. We have already noted that a cell of a storage battery delivers current at the rate of two volts, regardless of the size of the cell. Therefore, if we require a current with a force of six volts we must use three cells.

30. The size and number of plates in each cell will depend upon the amount of current needed and the length of time during which it is required. If only three cells were required to light one small lamp for a short length of time, we could use very small cells.

31. However, if we require current to crank a large automobile engine for any considerable period of time, we should require more surface in our plates, and should use cells containing quite a number of fairly large plates.

32. It is an easy matter to increase the capacity of a battery so that for a given weight it will discharge a proportionately large amount of current. This may be done by using a large number of very thin plates. Or, the rubber separators may be discarded, leaving room in the cell for a greater number of plates.

33. Often both these means are used, and a battery is built having very thin plates with only wood separators between them. Naturally, the thin plates have a shorter life than the thicker ones, and durability is further sacrificed when the rubber separators are omitted.

34. Any storage battery manufacturer who knows his business can build batteries with either thin or thick plates, and either with or without rubber separators.

35. It has been repeatedly asserted that excessive overcharging does no harm to the battery, but this statement has never been made by a reputable storage battery manufacturer. We need only pause for a moment to consider the action in a battery to be convinced of the damage resulting from overcharging.

36. So long as the battery is not fully charged, there is a ready combination between the elements of the solution and those of the plates. When the battery is fully charged, there is no longer any material in the plates with which the elements of the solution may combine, and they must be discharged from the solution in the form of gas bubbles, exactly as the gases were released in the first experiment described.

37. This bubbling or "boiling," as it is called, results first in rapid evaporation of the water of the solution, and if the water is not renewed frequently to replace this evaporation, the plates will be exposed to the air with harmful results.

38. The second and more serious effect of this boiling action is to loosen the active material from the plates. This material crumbles away and falls to the bottom of the jar. Under these conditions the battery will soon become useless. A battery which under proper charging conditions might last for three years could very easily be put out of commission in three months by continued overcharging.

39. First. The storage battery is a device in which certain chemical compounds are produced when it is charged; that is, when a current of electricity is passed through it from an outside source, and that this chemical action reverses when the battery discharges and gives back electric current and the original compounds are reformed.

40. Second. The essentials of all lead storage batteries are the same, and batteries differ only in the chemical construction of their parts.

41. Third. While the capacity of a battery may be increased by various means, this result can only be accomplished at the expense of durability.

42. Fourth. Satisfactory service from a storage battery depends largely upon the manner in which it is charged.

THE STORAGE BATTERY

1. Note. The gravity readings, proportions of sulphuric acid and water used in making electrolyte, height of solution in cells, charging rates and material of battery jars in the following information pertains to the storage battery, as applied to automobile electric systems; other information pertains to all lead plate batteries.

2. A storage battery is composed of rubber jars, lead plates, plate separators, and electrolyte.

3. The plates are made by first casting lead into grids. Then a composition made of lead oxides is pasted into these grids. This composition is better known as active material. This active material sets hard like cement when dried.

4. After the active material is compressed into the grids they go through an electro chemical process that converts that of the positive plates into brown peroxide of lead and that of the negative plates into spongy metallic lead.

5. The jars are made of rubber to prevent the acid from affecting them. There are always three cells in a 6-volt storage battery. These jars are so constructed that the plates rest on a stool about one inch from the bottom of the jar. This space is for the sediment that will accumulate as the battery wears.

6. The plate separators are made of either wood or hard rubber. They are used to separate the plates of different polarities from each other. Also to prevent foreign substances from causing short circuits.

7. The electrolyte or exciting fluid is made by mixing chemically pure sulphuric acid with distilled water in definite proportions.

8. The gravity of water is 1.000 and that of acid is 1.840. Mixing of 2 parts of acid with 5 parts of water should make electrolyte of about 1.300 gravity.

9. To make electrolyte, first secure an earthen vessel of a desired size. Pour the distilled water into the vessel and then add the acid. Be sure to add the acid slowly and stir all the time it is being added.

10. We would suggest the following: If 7 gallons of solution is to be made, first pour 5 gallons of water into the vessel and then add the acid as follows, until two gallons have been added; pour one quart of the acid into the water slowly and stir while so doing; let set 15 minutes, and then add another quart in the same way.

11. Continue this operation until the two gallons of acid have been added. Always be sure to use only distilled water and chemically pure sulphuric acid. When the above solution is cooled the gravity should be about 1.300.

12. If it is above this a little water should be added, and if below 1.300 a little acid should be added. Be sure that the solution is in a cooled condition when testing the gravity.

13. Any water used in a battery should be distilled. Water contains minerals, salts, etc., which are injurious to the active materials. Distilled water for a storage battery should be kept in bottles and corked up tight.

14. The true gravity of the solution in a storage battery can only be ascertained by charging the battery until the gravity of the solution has ceased to rise for a period of at least two hours.

15. As a battery is being charged the acid is forced out of the plates and mixes with the water and the gravity of the solution increases. As a battery is being discharged the acid leaves the water and goes into the plates and the gravity of the solution decreases.

16. When the battery is in a discharged condition the solution will test about 1.150. It should not be used when the gravity is this low, but should be given a charge at once.

17. If the gravity of the solution in a battery is low, add only distilled water until the plates are covered from ⅜″ to ½″ and then give it a charge. Charge until the gravity of the solution ceases to rise for a period of at least two hours. At this time the gravity of the solution should test between 1.275 and 1.300.

18. The rate a storage battery should be charged from an outside source depends entirely upon the size of a battery and state of charge. If the rated capacity of a battery is 80 ampere hours it should be charged as follows: When the gravity of the solution is below 1.150 or over 1.250, it should be charged at 5% of the rated capacity, or 4 amperes.

19. If the gravity of the solution is between 1.150 and 1.250, it should be charged at 10% of the rated capacity, or 8 amperes. The above are safe rates for any good battery.

20. Never add pure acid to a battery under any condition. Never add new electrolyte to a battery when it is in a discharged condition. If the solution in a battery tests low it is not a sure indication that the battery needs electrolyte.

21. The cells should be filled to the proper height with clean, distilled water and then put on charge and charged at the proper rate until the gravity ceases to rise for about two hours. If the gravity fails to rise to 1.275 some of the old solution should be taken out and replaced with new electrolyte of a 1.300 gravity.

22. While on charge and nearing a fully charged condition a single cell of a storage battery will give off a pressure of 2.5 volts. A 3-cell battery under the same condition will give off a pressure of 7.5 volts. When the charging is ceased the pressure of a single cell will go back to 2.2 volts, or 6.6 volts for a 3-cell battery.

23. The color of the positive plates is brown and that of the negative plates is gray or lead color. When a storage battery is in a fully charged condition there is no electricity in it. Passing a current of electricity through a storage battery causes energy to be stored up in a chemical form which can be converted into an electrical form when desired.

24. Distilled water is made by boiling water, producing steam, cooling the steam which returns to water. Steam that is cooling must not come in contact with metals other than lead. Never use boiled water in a battery.

25. When water is boiled the part that is pure rises as steam and escapes, and the part that remains is the impurities, which are injurious to the active material in the plates of the battery.

26. Remember, in making electrolyte for a storage battery that 2 and 5 do not make 7. If 2 gallons of acid are mixed with 5 gallons of water it will not make 7 gallons of solution. In mixing the acid and water heat is produced and some of the water evaporates, causing quantity to diminish.

27. If there was no evaporation in mixing 2 parts of sulphuric acid with 5 gallons of water the gravity of this mixture would be 1.240. Enough water evaporates while the parts are being mixed to cause the gravity of the solution to be about 1.300 in a cooled condition. When making electrolyte be sure to pour the acid into the water slowly. It is very dangerous to pour the water into the acid.

28. If the gravity of the solution in a battery tests 1.300 it is an indication that the battery is fully charged. If some one has added electrolyte instead of water to replace evaporation the 1.300 test will be misleading.

29. To be sure of the true gravity keep the battery on charge until the gravity has ceased to rise for two hours. Never let the plates remain exposed to the air for any length of time.

30. Distilled water should be added to a battery in use, at least twice a month. In cold weather never add water to a battery and let the battery set in a cold place unless it has been given a charge after the water was added.

31. Water is lighter than electrolyte and will remain on top and freeze if not mixed

with the electrolyte. The terminals of a storage battery should be kept tight and free from corrosion.

32. If the terminals of a storage battery show signs of corrosion, the corrosion should be removed at once. Take all bolts, nuts, washers, and straps off that can be removed readily and clean them with a strong solution of cooking soda and water.

33. Put all parts taken off the battery into soda solution and set aside for half an hour. Then use a short, stiff brush and remove all signs of corrosion. Also clean terminal posts of the battery, being careful not to let the soda solution get into the battery.

34. Wipe all parts dry and give them a good coat of vaseline. After these parts are assembled another coat of vaseline should be given them. If terminals are kept coated with vaseline, corrosion will not occur.

35. Use a filling syringe when adding water to a battery. Be sure that the top of the battery is dry and free from foreign substance, as such will cause short circuits between the terminals and the cells. A fully charged battery testing about 1.300 will freeze at about 90 degrees below zero, and when discharged down to 1.150 it will freeze at about 10 degrees above zero.

36. Keep the battery and its compartment dry in outer appearance. The wearing of a battery causes sediment to accumulate in the bottom of the cells and must be removed.

37. If sediment is high enough to short circuit across the lower ends of the plates it will cause the battery to overheat, gas excessively, gravity will rise slowly, and when the current is cut off for charging the voltage of each cell will drop below 2.2 volts per cell and continue to drop. The gravity of the solution will continue to drop, and in a short time the battery will be discharged whether used or not.

38. To remove sediment from a battery fill each cell with water to the proper height and place on charge. Charge until gravity in all cells ceases to rise for two hours. Remove plates, set plates in earthen vessel and cover with water. Clean sediment out of cells and wipe them dry. Fill cells about ¼ full of new electrolyte.

39. Then set the plates into the cells, one set at a time, and immediately cover with new electrolyte. Be careful not to expose to air long. Discharge plates back to a point where the gravity of the solution tests 1.200. Then charge until gravity in all cells ceases to rise for two hours.

40. Voltage tests of storage batteries can be made to show the condition of batteries very accurately, provided they are made in the proper way.

41. Voltage tests with the battery idle may be very misleading. A storage battery may be three-fourths discharged and while idle show a voltage almost equal to that of a fully charged battery.

42. The voltage of a battery in this condition will drop as soon as current is taken from it. The greater the rate at which you attempt to take current from the battery, the greater the drop in voltage. If a few lamps are turned on the voltage drop may be comparatively small, but if an attempt is made to crank the engine, just as soon as the circuit is completed by closing the starting switch the voltage drop will be excessive.

43. Remember this: A storage battery may be almost discharged and while idle show a voltage of two volts per cell, 6 volts for a 3-cell battery, or 32 volts for a 16-cell battery. If an attempt is made to crank the engine, the voltage of this battery may drop as low as 4 volts for a 3-cell battery or 20 volts or less for a 16-cell battery, this being due to the attempted high rate of discharge.

BATTERY INSTRUCTION

1. A single cell of a storage battery is composed of a glass jar, lead plates, plate separators, and electrolyte.

2. The cells of a storage battery are connected in series. This method of connecting is general with Automobile batteries.

3. The voltage of a fully-charged cell of a battery is about 2.2 volts.

4. While a battery is in charge the voltage of a single cell will rise as high as 2.5 volts.

5. The terminals of a storage battery are marked so as to distinguish the polarity.

6. The positive terminal is marked ("+") or "Pos." The negative terminal is marked ("—") or "Neg."

7. If the marks have been removed, a voltmeter may be used to distinguish the positive from the negative terminal.

8. The composition of the active material in the positive plates is principally red lead, and that of the negative plates is litharge.

9. The plates are made by first casting a lead alloy into the form of grids, and then compressing active material into them.

10. The plates are then allowed to dry. Active material in drying sets hard like cement.

11. After the plates are dried they are taken through an electro chemical process, which converts the active material of the positive plates into brown peroxide of lead, and that of the negative plates into spongy metallic lead.

12. The color of the positive plates is brown, and the negative plates is gray or lead color.

13. The jars are usually made of rubber or some good composition.

14. The jars are sometimes made of glass. This applies particularly to batteries used for stationary work.

15. Battery jars are made of rubber or glass, so acids will not affect them.

16. In the wear of a storage battery the active material slowly wears away and lodges in the bottom of the jars. This is called sediment.

17. The sediment chamber is always made large enough to contain the sediment that will accumulate.

18. The separators of a storage battery are made of either rubber or wood. In some batteries both wood and rubber are used.

19. These separators are placed between the plates of different polarity to prevent them from getting together and short-circuiting.

QUESTIONS

1. What is a single cell of a storage battery composed of?
2. How are the cells connected?
3. What is the voltage of a single cell when fully charged?
4. How high will voltage rise while on charge?
5. Are the terminals of a battery marked?
6. What are the marks?
7. If the marks have been removed, how can it be tested for polarity?
8. What is the composition of the active material?
9. How are the plates made?
10. Is the active material soft or hard when dried?
11. What is done after the plates are dried?
12. What are the colors of the plates?
13. What are the jars made of?
14. Where are glass jars used?

15. Why are they made of rubber or glass?
16. What is sediment?
18. What are separators made of?
19. What are they for?

20. The solution in a storage battery is called electrolyte.

21. Electrolyte is a mixture of chemically pure sulphuric acid and distilled water.

22. The proportions of acid to use in making electrolyte is two parts of acid to five of water.

23. Be sure that the water is distilled and that the acid is chemically pure.

24. When making electrolyte, measure the parts in it by volume and not by weight.

25. Use a glass or earthen vessel to mix the solution in. Never use metal other than lead.

26. Always place the water in the vessel first and then add the acid. Never add water to the acid.

27. Add the acid slowly, being sure that the proper proportions are used.

28. If acid was added too fast there would be excessive heating, which may cause the vessel to be cracked.

29. When adding the acid, always stir the solution. This will assist in preventing overheating as well as thoroughly mixing the acid and the water.

30. Use a clean wooden paddle to stir with. Be careful not to use a piece of wood that has been stained or painted.

31. The gravity of water is 1. It is usually marked 1.000. In fact, gravity is based upon the weight of water.

32. The gravity of chemically pure sulphuric acid is 1.840. This means that a pint of chemically pure sulphuric acid is 1.840 times as heavy as a pint of distilled water.

33. Sulphuric acid is a mixture composed of sulphur, oxygen, and hydrogen in definite proportions.

34. In the operation of a storage battery the acid does not evaporate, and none will be lost unless a battery is upset or is overcharged excessively or too fast.

35. The water used in mixing electrolyte will evaporate slowly as the battery is charged or used.

36. To replace evaporation in a storage battery, always use distilled water if it is possible to get it.

37. Use only distilled water in making electrolyte. Keep the water for this purpose in glass jars, and keep it clean.

38. Never use electrolyte to replace evaporation. If it is used, the gravity of the solution will be too high and cause injury to the plates.

39. Rain water may be used in case of emergency. If rain water is used it must be pure. It must not come in contact with metals of any kind.

40. Never use boiled water to replace evaporation. Boiled water contains impurities that are injurious.

41. Distilled water is made by boiling water, catching the steam that rises and cooling it without coming in contact with metals other than lead.

QUESTIONS

20. What is the solution in a battery called?
21. What is electrolyte?
22. What are the proportions?
24. Are the parts measured by volume or weight?
25. What kind of a vessel should be used in making electrolyte?

26. When making electrolyte, which part is added to the other?
27. How fast should the solution be added to the other?
28. Why so slow?
29. What else should be done while mixing?
30. What should be used to stir the mixture?
31. What is the gravity of water?
32. What is the gravity of chemically pure sulphuric acid?
33. What is sulphuric acid?
34. Does acid evaporate?
35. Does water evaporate?
36. What should be used to replace evaporation in a battery?
37. What kind of water should be used in making electrolyte?
38. Why not use electrolyte to replace evaporation?
39. Can rain water be used?
40. Can boiled water be used?
41. How is distilled water made?

42. Distilled water may be purchased from distilleries or local dealers, but should be kept in the container (glass) in which it comes.

43. Never add pure acid to a battery. This practice has been followed often, with a result that the battery life was very short.

44. If a battery is put on charge and charged until the gravity in all cells ceases to rise for two hours and the gravity is too low, new electrolyte should be added.

45. When a battery is fully charged the gravity of the electrolyte should be between 1.275 and 1.300.

46. There is only one sure method of telling when a battery is fully charged. That is, to put the battery on charge and charge it for a period of two hours after the gravity in all cells ceases to rise.

47. If the gravity is too low at this time, remove some of the old solution and add 1.300 electrolyte.

48. If the gravity is too high, remove some of the solution and add only distilled water.

49. The amount of solution to take out of a battery in either case depends upon the lowness or highness of the gravity. Take a little out at a time and use judgment.

50. If new electrolyte has been added to replace evaporation, the gravity will be too high.

51. A storage battery is charged by passing a current of electricity through it continuously in the same direction.

52. We do not store electricity in a battery. When a battery is fully charged there is no electricity in it.

53. The flow of current through a battery causes energy to be stored in a chemical form which can be converted into an electrical form when desired.

54. The rate a battery should be charged from an outside source depends entirely upon its condition and state of charge.

55. As an example, say we have an 80-ampere hour battery. If the gravity of the electrolyte is below 1.150 or over 1.250, charge at 5% of the rated capacity, which is 4 amperes. If the gravity is between 1.150 and 1.250, charge at 10% of the rated capacity, which is 8 amperes.

56. The reason for these different rates is that when a battery is real low, a high charging rate would buckle the plates and when nearly charged too high a rate may cause loss of active material.

57. Distilled water should be added to a battery often enough that the plates are never exposed to the air.

58. The length of time between intervals depends upon temperatures and treatment of the battery.

59. Ordinarily every two weeks is sufficient. In summertime it may be necessary to add water weekly.

60. Enough water should be added to keep the plates covered at all times.

61. When adding water, use a filling syringe, and be careful never to spill water over the top of the battery.

62. Water on top of a battery will cause dirt to accumulate.

63. This accumulation of foreign substances will cause short circuits between the terminals of the battery.

64. If water is added in wintertime, always charge the battery immediately afterwards.

65. Water is lighter than the electrolyte, and may lay on top and freeze

66. Charging the battery causes the water to mix with the electrolyte.

QUESTIONS

42. How should distilled water be kept?
43. When should acid be added to a battery?
44. When should electrolyte be added?
45. Between what points should the gravity rise when fully charged?
46. How do we know when a battery is fully charged?
47. What should be done if gravity is too low at this time?
48. What should be done if the gravity is too high?
49. How much solution should be taken out of a battery in either case?
50. What would cause the gravity to be too high?
51. How is a storage battery charged?
52. Do we store electricity in a battery?
53. What is done?
54. How fast should a battery be charged from outside source?
55. What would be a safe rate?
56. Why this difference in rates?
57. How often should water be added?
58. How much time between intervals?
59. What would be a safe time?
60. How much water should be added?
61. How should water be added?
62. Why?
63. What effect will water have on the top of a battery?
64. When should water be added to a battery in winter?
65. Why not any time if the solution is low?
66. What does charging do to the water?

67. Charging or discharging a storage battery causes the gravity of the electrolyte to change.

68. When a battery is being charged, acid is leaving the plates and mixing with the solution and the gravity rises.

69. When a battery is being discharged, the acid is leaving the water and going into the plates and the gravity drops.

70. When the gravity of the solution in a battery drops to 1.150 it is nearly discharged.

71. There is little danger of a battery freezing if it is kept charged up properly. It will freeze if it is only partly charged or in a discharged condition.

72. The freezing of a batterv also depends upon the temperature as well as the state of charge.

73. If the gravity of the solution is up to 1.300 it will freeze at about 90 degrees below zero.

74. If gravity is down to 1.150 a battery will freeze at 10 degrees above zero.

75. Gravity tests should be made when the battery is being charged or discharged.

76. If the voltage of a battery falls rapidly when charging is stopped and continues to fall until below 2 volts per cell, it indicates a short circuit, which quite likely is due to sediment being high in the sediment chamber.

77. The voltage of a storage battery is a good indication of state of charge if these tests are made in the proper way.

78. To test for bad cells, operate the electric starter and test each cell separately while starter is on. If part of cells are low it indicates bad or weak cells. If all are low, the trouble is generally due to discharge.

79. Type S. 1. hydrometers, made by The Electric Storage Battery Company, of Philadelphia, Pa., are correct and can always be relied upon.

80. Many makes of hydrometers are purely guessing devices, and they vary from 20% to 30% in their readings.

81. An ammeter must not be used to test a storage battery.

82. Connecting an ammeter across the terminals of a battery is the same as short circuiting the battery. The meter will quickly be burned out.

83. When a battery is being charged, acid fumes arise and often cause corrosion of the battery terminals.

84. Corrosion will be noted by the formation of a greenish deposit on the terminals. It may be necessary to take them apart to detect it.

85. Corrosion of battery terminals causes high resistance connections.

86. This will cause the battery to be slow to charge, and cranking will be slow, due to the high resistance in the battery terminal connections.

QUESTIONS

67. What causes the gravity of a battery to change?
68. Why when on charge?
69. Why when on discharge?
70. What is the gravity of a battery in practically a discharged condition?
71. Will a battery freeze?
72. At what temperature?
73. At what temperature when fully charged?
74. At what temperature when gravity is about 1.150 (about discharged)?
75. When should gravity test be made?
76. What is wrong if the voltage of a battery falls rapidly when charging is stopped and continues to fall until below 2 volts?
77. Is the voltage a sure indication of state of charge?
78. How should tests be made to detect bad cells?
79. What kind of hydrometer is best?
80. Are all hydrometers good?
81. Can a battery be tested with an ammeter?
82. Why not?
83. What effect has battery fumes on terminals?
84. How can corrosion be detected?
85. What is the effect of corrosion?
86. What effect has corrosion on operation?

87. All battery containers should be ventilated so the fumes can escape; otherwise they have a tendency to cause corrosion.

88. A strong solution made of cooking soda and water is best to use in loosening and removing corrosion.

89. Use about 6 tablespoons of cooking soda to one-half pint of water. Stir well before using.

90. To remove corrosion, remove all the nuts, bolts, and other parts possible and place them in the cleaning solution.

91. Allow these parts to remain in the solution for about one-half hour.

92. This does not remove the corrosion. It only loosens it so it can be removed.

93. Then use a short, stiff brush. It may be necessary to scrape the parts to get it all off.

94. Then dry the parts thoroughly and coat with vaseline or cup grease.

95. To clean the terminal posts of the battery, apply the solution to them with a brush, being careful not to get this solution in the battery. Then scrape or brush them until the signs of corrosion are gone.

96. Then dry and coat each terminal well with vaseline.

97. Then assemble these parts complete and give them a good coat of vaseline.

98. After this coat the terminals about twice a year with vaseline, and corrosion will not affect them.

99. The vaseline prevents acid or acid fumes from coming in contact with the terminals and prevents corrosion.

100. The terminal parts of a new battery should be removed and coated well with vaseline and assembled. Then give another coat of vaseline.

101. The top of a battery should be kept clean and free from foreign substances. If not, short circuits will occur.

102. To clean the top of a battery, use the same solution as used on the terminal parts. Allow to remain for five minutes, then wipe dry.

103. Excessive gassing of a battery while on charge may be due to charging too fast, over-charging excessively, or sediment high enough in the sediment chamber to short-circuit the plates at the lower end.

104. Overheating while charging, excessive gassing, or slow drop in voltage is an indication that sediment is causing short circuits.

105. The best way to test for this is to charge battery up full. Then take gravity reading. At the end of 24 hours take another reading. Gravity will continue to drop if short circuits are the cause.

106. It is always best to communicate with the maker of a battery or one of its service stations. They know what should be done.

107. Lack of charge will cause sulphation and hardening of the plates.

QUESTIONS

87. Why should a battery be ventilated?
88. What should be used to loosen corrosion?
89. How much of each?
90. What should be done first when removing corrosion?
91. How long should they remain in this solution?
92. Does this remove corrosion?
93. Then how should it be removed?
94. What should be done next?
95. How are the terminal posts cleaned?
96. What should be done then to the posts?
97. After the parts are assembled, what should be done?
98. How often should vaseline be applied?
99. What is the use of vaseline?

100. What should be done to the terminals of a new battery?
101. What will result if foreign substances accumulate on the top of a battery?
102. How should they be removed?
103. What will cause excessive gassing or overheating of a battery?
104. What are indicators that battery plates are short circuited?
105. How would be a good way to test this?
106. If sediment is high, what should be done?
107. What will cause sulphation of battery plates?

108. Sulphation seals the pores of the active materials and will ruin a battery if it is left in the condition for long periods.

109. Charging a battery removes the sulphation and continues to remove it until the battery is fully charged.

110. If a battery has been standing in a discharged condition or the gravity is extremely low, charge at an extremely low rate until the gravity is up to 1.150. Then complete the charge in the usual way.

111. If a battery is to remain idle for several months, it should be filled with distilled water the proper height and then charged full. Should be given a refreshing charge once every two months while idle.

112. The battery should be charged each time when giving refreshing charge until gravity is up.

113. A battery out of service may be charged from the system in the car or taken out and charged from an outside source, if desired.

114. If a battery is allowed to stand in a discharged condition the sulphation on the plates will harden. It will be hard to remove by charging, which will cause short life of the battery.

115. The term "ampere hour" means the number of hours a battery may be discharged at a one-ampere rate. A 100-ampere hour battery will supply current at a one-ampere rate for 100 hours.

116. The higher the rate of discharge the lower the efficiency. If the same battery was to be discharged at a 100-Ampere rate, it would supply current only 15 or 20 minutes at the most.

117. Direct current must always be used to charge batteries.

118. Alternating current may be used by using a rectifier, which converts it into direct current.

119. The Edison or General Electric Co. rectifiers are good and reliable.

120. To test for polarity of charging wires, fill a glass with water, add salt and stir well. Then dip the ends of the charging wires into the solution, keeping them at least an inch apart. Bubbles will arise from the negative wire.

121. Then connect the negative wire to negative terminal of the battery and the remaining wire to the positive terminal of the battery.

122. The user of a battery should keep the top of cells dry and free from foreign substances. Keep fully charged. Keep plates covered by adding only distilled water at frequent intervals, and note that terminals do not corrode.

QUESTIONS

108. What effect has sulphation?
109. How is sulphation removed?
110. At what rate?
111. What should be done to a battery that is to be idle for months?
113. Should the battery be taken out of the car to charge it?
114. Does excessive sulphating shorten the life of a battery?

115. Explain the term "Ampere hour."
116. Give effects of high discharge rate.
117. What kind of current must be used to charge batteries?
118. Can alternating current be used?
119. What can be secured to rectify this current?
120. Give method of finding polarity of charging wires.
121. How should charging wires be connected to a battery in reference to polarity?
122 Give user's care of a battery.

MOTORS

A Motor is constructed in the same way as a generator, and the term motor does not refer to the way the machine is built, but to the way in which it is used. Any direct current machine may be used as a motor or generator. If a machine is to be used as a generator only, it will be designed to give the best efficiency for that purpose, while its efficiency as a motor might be very low, and the same thing applies to a motor. We have defined a motor as a machine used to convert electrical energy into mechanical energy. This means that we reverse the order of things found in a generator, and instead of revolving the armature by use of mechanical energy and obtaining electrical energy from the brushes, we introduce electrical energy at the brushes and so cause the armature to revolve. The power thus delivered by the armature can be used in any desired way, as, for example, when we connect the armature shaft to the crank shaft of an automobile engine for the purpose of cranking. This connection is made by means of gearing.

GENERATORS

Fig. 8, page 61, shows two magnets placed with the north pole of the one toward the south pole of the other, showing lines of force flowing from the North Pole to the South Pole through the air, and we will use a simple diagram of this to illustrate the principles of a generator. Fig. 9, page 61, shows the two magnets mounted on a steel frame which also acts as a return path for the magnetism or lines of force. Magnetism flows much more readily through iron or steel than it does through air. By introducing the steel frame we have cut down considerable resistance to the flow of magnetism by shortening the path through the air.

Now, if we take a loop or coil of insulated wire with the two ends connected together, and revolve this loop or coil between the poles of the magnets, we find that a current of electricity begins to flow, or is said to be generated in, the coil of wire; but remember, that we must have magnetism or lines of force flowing from one pole to the other, and we also must have a completely closed circuit in the loop or coil of wire before any current will be generated in it.

Fig 10, page 61, shows the coil placed in such a position that the lines of force are flowing through the coil. If we now give the coil one-half revolution, we will see that in order to do so, we must cut all the lines of force that were previously flowing through the coil, and the same things happen every half revolution. This would cause the current generated in the coil to reverse its direction of flow every half revolution, which means that we would have an alternating current in the coil. An example of this will be found in the Magneto.

In order to obtain current or continuous current, as it is sometimes called, that is, current flowing continuously in the same direction, and not alternating, we must have some means of preventing the alternate reversal of the flow of the current after it leaves the generator. This is done by means of the Commutator, which is composed of a number of segments of copper. Fig. 11, page 61, shows the single coil, having one end connected to segment "A" of the commutator, and the other end connected to segment "B." Brush "C" is in contact with segment "A," and brush "D" is in contact with segment "B," the circuit through the coil being completed by means of a wire connecting brushes "C" and "D," called the external circuit.

The direction of the flow of current in the coil and in the external circuit is shown by the arrows. Notice that it flows from "B" to "A" in the coil, and from "C" to "D" in the

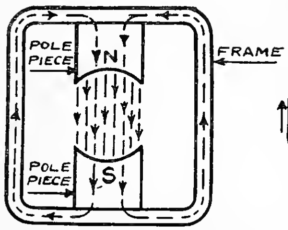


FIG. 9

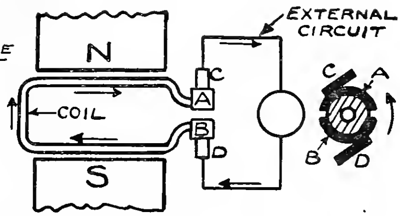


FIG. 11

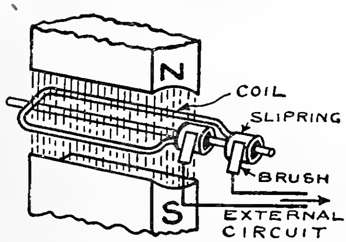


FIG. 10

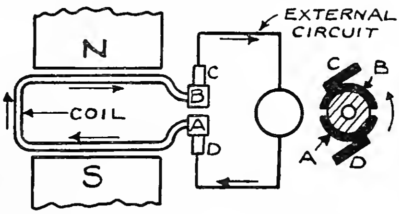


FIG. 12

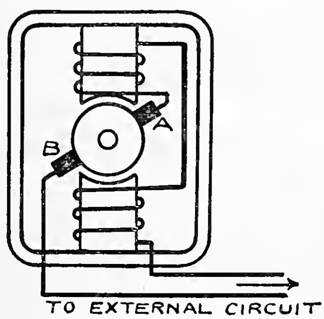


FIG. 13

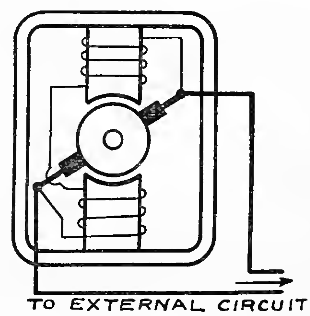


FIG. 16

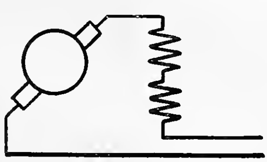


FIG. 14

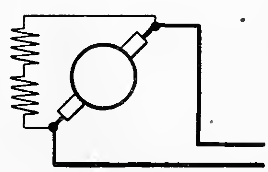


FIG. 17

external circuit. When the coil has revolved through half a revolution segment "A" will be under brush "D," while segment "B" will be under brush "C," as shown in Fig. 12, page 61. This means that although the current has reversed its direction in the coil, it is still flowing in the same direction through the external circuit or wire joining "C" and "D."

Notice that current flows from "A" to "B" in the coil during this half revolution, while the direction is the same in the external circuit as in the first half revolution, that is, from "C" to "D." In this way we have a flow of current always in the same direction through the external circuit.

An armature consists of a steel shaft upon which are placed a number of iron disks, slotted out to receive a number of coils similar to the one described, and these coils are connected to the segments of the commutator, which is also mounted on the same shaft. As each coil in turn revolves through the magnetic field, current is generated into it, and the brushes are placed in such a position that they collect this current from the various coils and deliver it to the "line" as it is called. This current may be used for charging batteries or for any other purpose where direct current is required.

We will now explain how magnetism is produced in the pole pieces. This can be obtained in two different ways: First, by means of permanent magnets as used on magnetos where there is no regulation of current. Second, by means of Electro Magnets for the pole pieces, when we wish to regulate the amount of current generated.

Series Wound. Fig. 13, page 61, shows how the current is taken to magnetize the poles of a Series Wound Machine. It will be noticed that all the current generated in the armature passes out of brush "A," and from there goes through the upper field coil, as it is called, then through the lower field coil before it passes out to the line, the return circuit being completed through brush "B." Fig. 14, page 61, illustrates how this circuit is shown in a simplified way.

Shunt Wound Machine. This type of generator is so called because only a part of the current flows through the field coils to magnetize the pole pieces, or to "excite the field," as it is usually called. The word shunt really means to switch or divide the flow of current. In this machine some of the current is switched off the main circuit and goes through the field coils. This machine is shown in Figs. 16 and 17, page 61, the latter being a simplified machine.

WATER ANALOGY

The following analogy or comparison between the action of an electric system and that of a water system will explain some of the terms used. The pump (generator) forces the water (current) through the pipes (wires) at a certain number of pounds (volts) pressure, as indicated by a pressure gauge (voltmeter) to overcome the friction resistance of the pipes (wires) in order that the water (current) may flow at the rate of so many gallons (amperes) per hour, as indicated by a water meter (ammeter). If the pipes (wires) are too large the cost will be too great. If they are too small the loss will be too great. The pipes (wires) might be so small that the friction (resistance) would absorb a very large portion of the power of the pump (generator), leaving little remaining for useful effect. The pipes (wires) require valves (switches) to regulate and direct the flow of water (current) without leak (drop) and safety relief valves (fuses) must be provided to prevent damage from over-pressure (over-voltage).

MOTORS AND GENERATORS

1. A Motor is a machine used to convert electric energy into mechanical energy.

2. A generator is a machine used to convert mechanical energy into electric energy.

3. The most important parts of a motor or generator are the frame, pole pieces, armature, field coils, and brushes.

4. The material in the frame of the best generators is made of drop-forged steel.

5. Drop-forged steel is an excellent conductor of magnetism, and more lines of force can be produced from the same volume of metal.

6. The part of the metal frame surrounded by the field coils is called "pole pieces."

7. The metal on the end of the pole piece next to the armature is often called the "pole shoe." In the construction of most machines it is a part of the pole piece.

8. The armature of a motor or generator is the revolving part of the machine. The armature of an electro magnet (cut-out relay) is the moving part of the electro magnet.

9. The armature of a motor or generator is located in the center of the machine, and is mounted in bearings which are located in the end frames.

10. In the operation of a motor or generator the armature revolves continuously.

11. An armature is composed of a shaft, laminations, commutator, wire, and insulating material.

12. The laminations, with slots cut in their outer edges, are assembled on the shaft along with the commutator. Into the slots of the lamination the insulated wire is wound, the ends of the coils of wire being connected to the commutator.

13. The commutator is composed of copper bars assembled side by side in a cylindrical form. The bars are insulated from each other with strips of mica. The bars of copper are called "segments."

14. The purpose of the commutator is to assist in making a flexible connection between the outer circuits and the windings of the armature. It also assists in reversing the direction of flow of current.

15. All currents generated into the windings of an armature are alternating currents.

16. By the use of the commutator and brushes these currents are converted into direct current as it leaves the commutator.

17. The brushes rest on the commutator and serve to make a connection to the windings of the armature.

18. When a machine is being used as a motor, current is being introduced into the windings of the armature.

19. When a machine is being used as a generator, current is taken from the windings of the armature.

20. The brushes of a motor or generator may be made of carbon, carbon and metal, or metal alone.

21. The commutator is fastened to the armature shaft and revolves with the armature.

22. Brushes are mounted in pockets and on arms. Mounting on arms is their best method.

23. Where pocket type mountings are used the brushes often stick up, due to dirt and gum, and fail to make good contact with the commutator.

24. When brushes are mounted on arms it prevents sticking up and assures even tension in the commutator.

25. The total end surface of all brushes should come in contact with the commutator.

26. If the total end surface does not make contact with the commutator, the resistance between the brush and the commutator will be increased.

27. To fit brushes to a commutator use a strip of about number "0" sand cloth the full width of the commutator, and insert between the brushes and the commutator with the rough side next to the brush. Then sand as shown in Figures 23 and 25, page 66. Care must be taken that the sand cloth is not pulled back and forth, as shown in Figs. 24 and 25, page 66, as this will cut the corners of the brushes away.

28. Emery cloth must not be used, as emery is a conductor, and may lodge between the segments of the commutator and cause short circuits.

29. Never lubricate a commutator. Lubrication in a commutator will cause dirt and gum to accumulate, which will cause poor brush contact and arcing.

30. The segments of a commutator are insulated from each other with strips of mica.

31. These mica insulations do not always wear as fast as the copper segments. This depends upon the material of the brushes used.

QUESTIONS

1. What is a motor?
2. What is a generator?
3. Name the most important parts used in the construction of motors and generators.
4. What is the material in the frames of the best machines?
5. Why is this best?
6. What is a pole piece?
7. What is a pole shoe?
8. What is an armature?
9. Where is the armature located?
10. How can it be distinguished?
11. Name the parts used in the construction of an armature.
12. How is the armature constructed?
13. What is a commutator?
14. What is the use of the commutator?
15. Are currents generated into the armature alternating or direct?
16. How are they converted into direct current?
17. What are brushes used for?
18. When is current introduced into the armature?
19. When is current taken from the windings of the armature?
20. What is the composition of the brushes?
21 Why is a flexible connection to the commutator necessary?
22. What is the best way to mount brushes?
23. What are the objections to pocket type brush holders?
24. What are the advantages of mounting brushes on arms?
25. How much of the end surface of the brushes should make contact with the commutator?
26. Why?
27. Give proper method of fitting brushes to commutator.
28. Should emery cloth be used?
29. Should a commutator be lubricated?
30. How are the commutator bars (segments) insulated from each other?
31. Do mica insulations wear as fast as the copper?

32. Carbon brushes are nearly always used on generators, and metite or metal brushes on motors.

33. Where metal or metite brushes are used the micas seem to wear away as fast as the segments.

34. When carbon brushes are used it is necessary to keep the micas grooved out below the surface of the commutator.

35. If, in the wear of the commutator, the micas become high, the brushes will not make good contact, and arcing and burning will result.

36. The armature must always be removed from the machine before the micas are grooved out.

37. When the armature is put in a lathe, the tool carriage should first be run along to see that it will not strike the armature while the commutator is being trued up.

38. Then the commutator should be trued up so it is perfectly round.

39. To start the groove in the micas use a three-cornered file, as shown in Fig. 18, page 66. This cuts the micas out so a hack-saw blade can be used.

40. After the groove is started with a file, use a piece of hack-saw blade the thickness of the mica to cut the micas out, as shown in Fig. 19, page 66.

41. If the hack-saw blade is too thick it can be ground down to the proper thickness.

42. The groove should be cut about one thirty-second of an inch below the surface of the commutator.

43. If the micas are not cut away they will break clean off and get under the brushes and cause arcing. See Figs. 20 and 21, page 66.

44. After grooving out the micas the commutator should be sanded and polished. Use dmeium fine sandpaper. Speed up commutator and sand as shown in Fig. 22, page 66. Pulling the ends of the sand paper back and forth. Then use cheese cloth and polish.

45. The commutator can usually be sanded while in the machine. To do so, first lift the brushes and then sand same as out of a machine.

46. Sandpaper must not be held on the commutator under finger pressure. It will cause grooves to be cut in the commutator.

47. Always refit brushes to a commutator after truing up and undercutting micas.

48. Coal Oil (Kerosene) should be used on a commutator to loosen up the dirt and gum.

49. Before applying the coal oil be sure to lift the brushes and not allow the coal oil to get on them.

50. Apply the coal oil to the commutator with a cloth, being careful to apply only to the commutator.

51. Allow the coal oil to remain on the commutator for about 10 minutes.

52. Always use cheese cloth to wipe a commutator. Never use waste.

53. Cheese cloth is nearly free of lint and is very soft and flexible.

54. If a cloth containing lint is used the lint will be caught in the segments and will prevent good brush contact, which will cause arcing.

55. Never use gasoline to clean a commutator. It will get into the winding of the armature and evaporate away slowly. When the machine is operated an explosion may occur.

56. When oiling parts of a car always oil the motor and generator.

57. The circuits of a motor or generator are called internal circuits.

58. External circuits is a term generally applied to the wiring used between different pieces of electrical apparatus.

59. When testing a machine do not use a buzzer. The resistance of many circuits that are good may be so high that a buzzer will not operate. Use a test lamp connected to a 110-volt circuit.

60. The term "shunt field" applies to a field winding that is connected directly across the brushes. See Figs. 16 and 17, page 61.

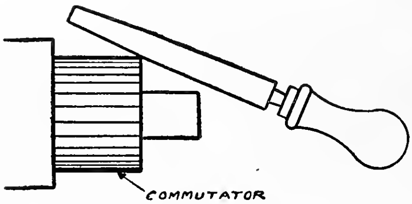
61. The term "series field" applies to a field winding that is connected in series with the brushes.

62. The care a user should give a motor or generator is to keep the commutator clean and the bearings lubricated.

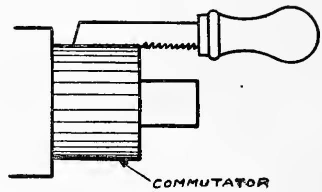
QUESTIONS

32. What kind of brushes are most commonly used?
33. With what kind of brushes do the micas wear as fast as the copper?
34. Where carbon brushes are used what should be done to the micas?
35. If, in the wear of the commutator, the micas become high, what will result?
36. Can the micas be ground out when the armature is in the machine?
37. What should be done first when the armature is put in the lathe?
38. What should be done then?
39. How should the grooves in the mica be started?
40. How should the grooves be finished?
41. What should be done if the hack-saw blade is too thick?
42. How deep should the groove be cut?

COMMUTATOR AND BRUSHES



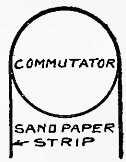
STARTING GROOVE IN MICA WITH 3-CORNERED FILE.
FIG.- 18.



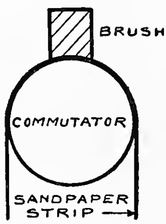
SLOTTING MICA WITH PIECE OF HACKSAW BLADE
FIG.- 19.

RIGHT WAY
MICA MUST BE CUT AWAY CLEAN BETWEEN SEGMENTS.
SLOTTING MICA
FIG.- 20.

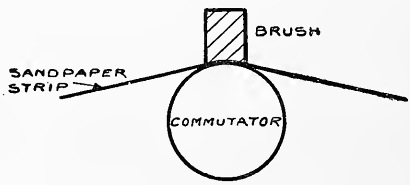
WRONG WAY
MICA MUST NOT BE LEFT WITH A THIN EDGE NEXT TO SEGMENTS
SLOTTING MICA
FIG.- 21



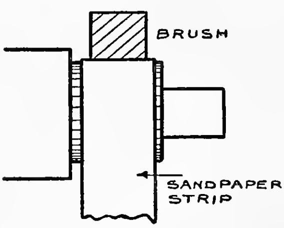
SANDING COMMUTATOR
FIG.- 22



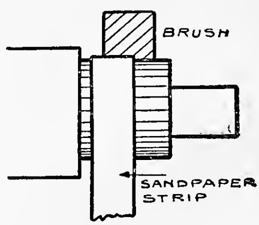
RIGHT WAY
FIG.- 23



WRONG WAY
FIG.- 24



RIGHT WAY
FIG.- 25



WRONG WAY
FIG.- 26

SANDING BRUSHES

43. What will result if the edges of the micas are not cut away clean?
44. What should be done to a commutator after grooving out the micas?
45. How can a commutator be sanded in a machine?
46. What will result if a piece of sand cloth is held on the commutator under finger pressure?
47. After grooving out micas, do the brushes require attention?
48. What can be used to loosen an accumulation on the commutator?
49. What should be done before applying coal oil?
50. How should coal oil be applied?
51. How long should the coal oil be left on the commutator?
52. What should be used to wipe a commutator?
53. Why cheese cloth?
54. What effect will lint have?
55. Why not use gasoline to clean a commutator?
56. How often should the bearings be lubricated?
57. What are the circuits of a motor or generator called?
58. What are external circuits?
59. What should be used to test a machine (motor or generator)?
60. What is meant by "shunt field"?
61. What is meant by "series field"?
62. What care should the owner of a car give a motor or generator?

SOLDERING

1. Very few mechanics or repairmen working on motor cars or electric devices as applied to motor cars realize the importance of soldering all joints or splices when they are made.

2. If a piece of wire is attached to another or to a terminal and taped up without being soldered, the connection will be of a very low resistance at the time, but corrosion of the parts will soon take place and offer added resistance to the circuit.

3. This will cause the system to work bad, and, as a rule, the trouble will be hard for the average man to locate. All connections should be soldered when they are made.

4. In soldering wires to terminal clips, care should be exercised that the solder does not flow over the portion of the clip that goes under a terminal.

5. When soldering a wire to a clip or making a soldered connection, the tinned side of the iron should be held close to the point where the solder is to unite the two parts.

6. The iron must be held still, that all the heat may be transmitted to one point, so the solder will flow freely. After soldering always test these parts to see that a good joint is made.

7. Another thing of great importance is the solution used in soldering. The following solutions are used: Soldering acid (cut muriatic acid), soldering salts, soldering paste, rosin, rosin dissolved in grain alcohol, and a solution known as ruby fluid.

8. To make soldering acid, dissolve zinc into muriatic acid until the acid becomes so weak that it will not dissolve any more of the zinc. This solution may be used with very good results on large work, but should never be used around insulated wire with a cloth covering.

9. If this solution is used as soon as the work is done the parts soldered should be washed with a strong solution of cooking soda and water, that all of the remaining acid is removed.

10. This acid is a conductor of electricity, and if left on the parts where soldering is done, it will cause light grounds or short circuits, which are very hard to find. Soldering pastes often cause the same trouble, as they are composed of substances as a rule that are high-resistance conductors.

11. Plain rosin or rosin dissolved in grain alcohol is an excellent solution to use. When this is used the parts to be soldered must be cleaned thoroughly.

12. To make this solution, dissolve rosin and grain alcohol into a solution like a thin syrup. If this solution becomes too thick at any time, add more grain alcohol and be sure to keep the container closed when not in use.

13. Ruby fluid is made by the Ruby Chemical Company, of Columbus, Ohio, and is used by many electrical manufacturers in their work. This solution does not act as a conductor, and can be used at all times with safety.

14. The size and shape of a soldering iron depends entirely upon the class of work to be done. When doing small work use about one-half pound iron with a medium sharp point. Never tin but one side of the iron, and then the flow of solder can be controlled at all times.

15. If the work is large, it is best to use an iron of from one to two pounds in weight. The point of the iron should be blunt. Remember that you are trying to solder, and not scrub, so hold the iron still when soldering.

16. Where an electric iron is used almost continually, it is best to make up a block with switch attached. Then connect a 32-candle power lamp in series with the iron. Then connect the switch so when closed it will short-circuit the lamp and let the required amount of current flow into the iron.

17. When not soldering, snap the switch off, which will let the light burn. This will reduce the amount of current that will flow through the iron.

18. Then there will be a saving of current, the iron will last much longer, point will remain tinned longer, and the iron kept warm enough that when wanted again it will only require a few seconds until it will be hot enough.

19. When tinning an iron the parts to be tinned should be cleaned and hammered first, then tinned. This will cause the tin to remain longer. Use a sal ammoniac solution to dip iron in when tinning.

QUESTIONS

1. Should all wire connections be soldered?
2. What will result if connection is not soldered?
3. Will this effect the working of a system?
4. What should be done when soldering wire to clips?
5. Give method of holding iron when soldering.
6. Why should the iron be held still as a rule?
7. Name some solutions used.
8. Give method of making soldering acid.
9. What should be done when acid is used?
10. If surplus acid is not removed after soldering, what will result?
11. Name one good solution that is not a conductor.
12. How is the solution made?
13. Is Ruby Fluid good? Where made?
14. Give size of irons to use.
15. What should be the shape of a heavy iron?
16. What should be done when using an electric iron?
17. What effect will a light have when connected in series with iron?
18. What benefits will result?
19. Give method of tinning an iron.

INSPECTION

1. It is a common error to suppose that a lot of instruments are necessary in order to locate electrical troubles of a Gas Engine electric system. A reliable voltmeter and ammeter test set (see Phillips test set, Model 302), page 70, is all that is necessary at any time.

2. The fact is that the greatest number of troubles arise from small causes, and in some cases instruments are not necessary in detecting these causes. The thing most needed is a solid understanding of the simple Principles of Electricity.

3. The next thing is to cultivate the useful habit of using your eyes to examine everything carefully. In the first place, all apparatus should be kept as clean as possible. Remember that dirt is one of the most common causes of electrical troubles.

4. For example, a very small piece of dirt getting between the distributor contact points will cause the failure of ignition. Dirt on a commutator causes arcing at the brushes, excessive wear of both brushes and commutator, low generator, output, etc.

5. Corroded connection may also be classed along with dirt, because corrosion acts in the same way and prevents the proper flow of current. Corrosion will usually be found on bolted connections where exposed to moisture or acid fumes. Storage batteries should be particularly examined from time to time to see that the terminals are clean and firmly fastened in place.

6. Loose wires and connections form another source of trouble. Therefore all connections should be carefully examined from time to time and cleaned and fastened securely. Defective insulation should be looked for and attended to at once.

7. Repair or replace all insulation that is cut, worn, or broken. Cut or worn insulation will usually be found where wires enter a circuit or where wires rub together or become chafed by rubbing on some metal part.

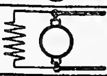
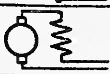
8. All wires should be firmly secured with the necessary cleats, and must not be allowed to hang loosely or unsupported. Broken insulation will usually be found in the shape of broken insulating washers, bushings, sleeves, etc. If any of these are broken or even cracked, they should be replaced with some new ones immediately.

9. Sometimes in reassembling apparatus an insulating washer or bushing may have been left out. Therefore examine carefully to see that no parts are missing. In almost all cases where trouble arises from any of the above-mentioned causes, a careful inspection will show where it is. In all cases of trouble a thorough examination should be made, as this will usually locate the cause and make further testing unnecessary.

QUESTIONS

1. What instruments are necessary in locating electric troubles?
2. What is most needed in locating electric troubles?
3. Name one of the most common causes of electric troubles.
4. Give two examples of dirt causing trouble.
5. Give the effects of corrosion.
6. What is meant by "defective insulation?"
7. What will cause defective insulation?
8. How should insulation be protected?
9. What precautions should be taken when reassembling apparatus?

SIGNS, SYMBOLS AND ABBREVIATIONS.

+	POSITIVE
—	NEGATIVE
⟶	ARROW INDICATES DIRECTION.
 OR C.W.	CLOCKWISE REVOLUTION.
 OR C.C.W.	COUNTER-CLOCKWISE REVOLUTION.
	COIL OF INSULATED WIRE. (COARSE.)
	COIL OF INSULATED WIRE. (FINE.)
A	AMMETER.
V	VOLTMETER
	SHUNT WOUND MACHINE.
	SERIES WOUND MACHINE.
	GENERATOR.
	MOTOR
	WIRES JOINED TOGETHER.
	WIRES CROSSING.
	RHEOSTAT OR VARIABLE RESISTANCE.
	INCANDESCENT LAMP.
	DRY CELLS OR STORAGE BATTERY. CELLS IN SERIES.
V	VOLT.
A	AMPERE.
D.C.	DIRECT CURRENT.
A.C.	ALTERNATING CURRENT.
K.W.	KILOWATT. (1000 WATTS).
H.P.	HORSE. POWER (746 WATTS).

SECTION 2

DRIVING THE CAR

DRIVING THE CAR

1. Before Leaving the Garage. See that there is sufficient gasoline and oil in the tanks to carry you the distance you wish to go. Examine the radiator or tank to see that it is full of water. Have sufficient air in the tires. All grease cups should be filled and turned down properly. If batteries only are used, two should be carried, and one of them fully charged.

2. If you are carrying only one battery, be sure that it is sufficiently charged to make the desired run. Have on the car at least one extra shoe, and three extra tubes, with the ordinary equipment of tire pump, jack, oil, gun, tire tools, tire patches and cement, and the regular kit of other tools.

3. A set of non-skid chains will be found very useful on wet asphalt. They should not be used, however, any more than is necessary, as they wear the tires excessively. A couple of extra spark plugs should be carried to save the trouble of cleaning a short-circuited one on the road.

4. Starting Crank. In a gasoline automobile it is found that the motor must draw a supply of gas into the cylinder and compress it before this charge can be ignited to expand and give power. It is therefore necessary to have some means of turning the engine over to accomplish this.

5. The starting crank, placed usually on the front of the machine, just in front of the radiator and between the front spring horns, is for this purpose. It is operated as a rule with the right hand, and is rotated clock-wise (the direction the hands of a clock travel). When there is a self-starter provided, the starting crank is carried in the tool box and is used only when the starter will not operate.

6. Starting Pedal. The starting pedal or button may generally be found somewhere on the floor board. Pressing on it connects an electric motor to the crank shaft of the engine and closes a switch that allows current from the storage battery to flow to the motor and crank the engine. This takes the place of the hand starting crank.

7. Clutch Pedal. It is quite often desirable to run the engine without moving the car and it will also be found necessary at times to bring into mesh different gears so that more power or speed may be obtained. A clutch is therefore placed between the engine and the rear wheels.

8. It is controlled by means of a pedal placed just back of the dash. The clutch is released by pressing on this pedal with the left foot, and when released the engine will continue to run, but will not deliver power to the driving wheels.

9. When the pressure of the left foot is released from the pedal the clutch will become engaged automatically by means of a stiff spring and the car will move forward or backward, according to which gears are in the mesh.

10. If the gears are in the neutral position, however, power will not be applied to the car when the clutch is engaged. The clutch must be released every time the gear shifting lever is moved and whenever the brake is applied.

Remember, it is **depressing or pushing** this pedal that overcomes the tension of the spring and **releases** the clutch, and when no pressure is applied to the pedal the clutch is **engaged.**

QUESTIONS

1. What should be done before leaving the garage?
2. Give lists of extra parts that should be carried in kit.
3. When should skid-chains be used? Why not all the time?
4. Explain the use of the starting crank.
6. Where is the starting crank located?
7. What is the purpose of the clutch pedal? Where located?
8. What is the purpose of the clutch? Where located?
9. Explain in detail the operation of the clutch.

12. The Running Brake Pedal. The running brake is used for bringing the car to a standstill. It is operated by means of a pedal placed just back of the dash and to the right of the clutch pedal. To apply the brake first release the clutch by pushing on the clutch pedal, then push down or forward on the brake pedal with the right foot, gently but firmly, until the car is stopped.

13. After removing the foot from the brake pedal the brake will be released automatically by means of a spring. Use the brake gently to save discomfort to the passengers, wear on tires, and the machine in general. Do not run close to the point where the stop is to be made and then jam the brake on hard, but begin early to apply it and bring the car to a standstill gradually.

14. Gear Shifting Lever. This lever is usually placed forward and to the right of the operator's seat, and to the left of the emergency brake lever. It is operated with the right hand. By shifting this lever, which engages different sets of gears, the machine may be made to go forward at different speeds while the engine turns at a practically uniform speed.

15. It also controls the reverse gear. When the car is standing the lever should be left in neutral position. When in this position, even if the clutch is engaged, the machine will not move. To start the car, release emergency brake, release the clutch with left foot, grasp the gear shifting lever with the right hand and shift from the neutral position to the first speed notch, accelerate slightly, then allow the clutch to engage slowly, and the car will start.

16. After the car has started release the clutch again and shift the gear lever to the second speed notch and engage the clutch quickly but gently. Repeat this operation for third and fourth speeds. **Always release clutch when shifting this lever.** Whenever the car is brought to a standstill, put the lever in the neutral position before applying emergency brakes.

17. Accelerator Pedal. This pedal operates the throttle on the carburetor and regulates the amount of gas going to the engine and thus controls the power which the motor develops. It is sometimes placed between the clutch and brake pedals, but usually to the right of the brake pedal, and is operated by the right foot.

18. More gas is permitted to enter the cylinder and therefore more power is obtained by pressing on it, and when released the throttle will be returned to its minimum position by means of a spring.

19. Push on the pedal very slowly, for a slight movement greatly increases the power developed by the motor, and a too sudden application of power will strain the whole machine. It should be pushed slightly when the clutch is engaged to increase the power of the motor, and should be released when the clutch is disengaged, so that the engine will not race.

20. The Throttle Lever. This lever controls the throttle on the carburetor the same as the accelerator pedal, but it has a spring latch and when it is desirable to run the machine for some distance at a nearly constant speed, this lever may be used, as it will stay placed, thus relieving the right foot, which would become tired holding the accelerator pedal in one position for a long time. It is usually placed on the steering post, above the steering wheel, and is operated with the right hand.

QUESTIONS

12. What is the purpose of the running brake pedal? Where is the running brake pedal located?
13. Explain operation of running brakes.
14. Explain operation and use of the gear shifting lever.
15. What should be done to the clutch when shifting gears?
17. Explain use of accelerator pedal. Where located?
18. Explain when to use and when not to use accelerator.
19. Give use and operation of the throttle lever.
20. Where is the throttle lever located?

21. The Emergency Brake Lever. The emergency brakes are used chiefly after the car has been stopped and the operator wishes to leave it. They are applied by means of a lever operated by the right hand. This lever is usually placed just forward and to the right of the driver's seat.

22. It is fitted with a spring latch and when applied will lock on, and so is very convenient in stopping on a hill or when the car is left standing at the curb. The brake is applied by pulling back the lever. This brake can be used alone or in connection with the running brake for quick stops when necessary, but it should not be used for ordinary stopping as it is usually not designed for such work.

Do Not Advance Throttle Lever Too Quickly.

23. The Spark Control Lever. It takes some time after the spark occurs for the gas to get thoroughly ignited and give power. It is therefore desirable to have the spark occur earlier when the engine is running fast, so that the gas may be thoroughly ignited at the beginning and deliver power for full length of the working stroke.

24. This means that the spark when advanced actually occurs when the piston is still traveling upon the compression stroke and so gets the gas in the cylinder at its maximum pressure when the crank passes top dead center.

25. When the motor is cranked in starting it is turned so slowly that to avoid a kick back the spark must be retarded so that it occurs after the crank has passed top dead center.

26. The spark control lever is connected with the spark timing device and so controls the time at which the spark occurs in the cylinder. It is usually placed on the steering column above the steering wheel, and is operated with the right hand.

27. On some cars it is moved forward and on others backward to advance the spark. When the engine is cranked in starting the spark should be fully retarded. After the motor has started it can usually be advanced about two thirds, but there is no set rule for this.

28. In general advance as the motor (not the car) gains speed, and retard as it slackens speed. Keep the spark advanced as far as possible at all times, but retard it as the engine labors or knocks.

29. Ignition Switch. Usually placed on the dash. It is for the purpose of closing and opening the electric circuit and thus stopping the motor or allowing it to be started. It is generally provided with a removable plug or key so that the car may be safely left at the curb. Be sure that switch is in "off" position when the motor is stopped.

30. Steering Wheel. The steering wheel is usually placed on the left-hand side of the car, directly in front of the operator's seat. By its means the direction of the car is controlled. When moving forward, turning the wheel counter clockwise will cause the car to go to the left and turning it clockwise will cause the car to go to the right.

31. It should be operated with the left hand only unless steering is very hard, when both hands may be used. Grasp the wheel firmly with one or both hands, but not with a strong, nervous grip, as this becomes very tiresome.

32. If the hand is always kept in one position on the wheel when only slight turns are desired, there will be no difficulty in knowing by its position when the front wheels are point-

ing straight ahead. When turning corners the position of the hand on the wheel may be changed and both hands should be used.

33. Do not attempt to turn the steering wheel when the car is not moving as this throws a very great and entirely needless strain on the whole steering mechanism.

QUESTIONS

21. Give use of spark control lever.
22. Explain advance and retard of the spark.
23. What would cause a back fire?
24. Will wrong position of throttle lever cause loss of power?
25. What should be the position of the throttle lever when running?
26. Give use of the emergency brake lever. Where located?
27. Give use of the ignition switch.
28. Where is it located? How operated?
30. Give use, location, and operation of the steering wheel.
31. Explain operation in detail.

34. Priming Device or "Choke". When the engine is cranked in starting it is turned so slowly that the air going in through the carburetor has not sufficient velocity to draw the required amount of gasoline from the spray nozzle. The mixture that goes into the cylinder is therefore weak and cannot be exploded easily.

35. To enrich the mixture a valve is placed in the carburetor air passage, to choke off the air and feed more gasoline to the motor. This valve is operated by a lever or button usually found on the dash or attached to the steering column under the steering wheel.

36. It is often combined with a device for making the mixture richer or leaner to take care of different weather conditions. Some engines will start nearly every time without priming the carburetor; others must be primed every time the engine is started. Do not prime to excess; as soon as the engine starts, return the lever or button to the running position.

37. The Gasoline Tank. The gasoline tank carries the fuel that is to be fed to the engine. It will sometimes be found under the front seat, and may be filled by removing the cushion. In this system the gasoline flows by gravity to the carburetor, and a small hole about the size of a pin will be found in the filler cap to allow air to enter as the gasoline leaves.

38. This hole should be kept clean, because if the air cannot enter the gasoline will stop flowing to the carburetor and the engine will stop running. Some cars carry the gasoline tank on the rear of the chassis, under the body, and air pressure is kept on the gasoline to force it to the carburetor.

39. This pressure is obtained by a hand pump placed on the dash, and is kept constant automatically. This system differs from all others in that there should be no hole in the filler cap of the tank and the gasket on the cap should be kept in good condition to prevent air leakage. A gauge will be found on the dash and by this means the pressure on the tank can be determined.

40. Other cars with the tank under the rear end of the chassis have a system of drawing the gasoline by means of a vacuum to a small tank located by the carburetor by gravity. Still other cars have a gasoline tank in the cowl of the dash from which the gasoline flows to the carburetor by gravity.

QUESTIONS

34. Give use of priming device or choke.
35. Explain its operation.
37. Why is a large gasoline tank necessary?
38. Describe three systems of supplying gasoline to the carburetor.
39. Is it necessary to have a hole in the filler cap of all gasoline tanks? Why?

41. The Lubricator. The lubricating system is generaly built into the crank case of the engine. The oil is supplied through a pipe or other opening found on the engine and gauge, or pet cock is provided to indicate the amount of oil in the motor. The system should be kept filled with a light to medium weight high-grade gas engine oil.

42. The lubricating system usually oils all internal parts of the engine only. The transmission, steering, and different gears being lubricated by heavy oil or grease placed in their respective housings, and all other parts of the cars are taken care of by oil or grease cups. Any oil put into the engine should be carefully strained to remove dirt or grit.

43. The Water Tank. The water tank or radiator is placed on the front of the car and should be kept filled with clear water. Any sediment that is allowed to enter the radiator will clog it and the engine will then overheat.

44. During the winter it is well to fill the radiator with some anti-freezing solution.

45. Alcohol is good for this purpose, mixed with water in the following proportions as desired:

46. 2 pints wood alcohol to 1 gal. water, freezes at zero.
2½ pints wood alcohol to 1 gal. water, freezes at 10 below zero.
3 pints wood alcohol to 1 gal. water, freezes at 20 below zero.
4 pints wood alcohol to 1 gal. water, freezes at 30 below zero.

47. If steam is discharged from the radiator, examine the fan directly back of it and the water pump, and see that there is no clog in the pipes leading to and from it.

48. Tires. Keep the tires free from oil and grease as they rot the rubber. Drive very carefully in wet weather because rubber cuts very easily when wet. Drive slowly around corners and start and stop without jerks; also be very careful not to rub the tires against the curb.

49. Have all small cuts vulcanized so that moisture cannot get in and rot the fabric. Do not run on a flat tire unless it has been damaged beyond repair. Run slowly on the rip, or wrap a rope around it if no other tire is to be had.

50. It is very important to keep the tires fully inflated at all times. If tires do not give satisfactory wear, report it to the manufacturer at once. When the car is to be laid up for some time, place jacks under it to keep the weight off the tires.

QUESTIONS

41. Why is lubrication necessary?
42. Describe a simple lubricating system.
43. Give use of the radiator.
44. What should be done to prevent freezing of water in winter?
45. What solution is most commonly used?
46. Give proportions to use for various temperatures.
47. What does a discharge of steam from a radiator indicate?
48. What effect does grease and oil have on tires?
49. What should be done when small cuts are detected in tires?
50. What should be done to the tires when car is laid up for the winter?

51. To Start the Motor. Place the gear shifting lever in the neutral position, put the emergency brake on, retard the spark fully or, if well acquainted with the motor, to a point where the spark will surely occur after the crank has passed top center.

52. Open throttle about one third (after getting acquainted with the machine you will find a position for the throttle where the motor starts best). Put the switch in "On" position. If the motor habitually starts hard, prime the carburetor with choking or enriching lever.

53. If the car is equipped with electric self-starter, press hard on starting button or pedal. When the engine starts remove foot from pedal immediately, then close throttle and advance spark lever two-thirds.

54. In cranking the motor by hand, grasp some part of the car with the left hand to

steady yourself, place the feet wide apart, and stand close to the front of the machine. Grasp the starting crank with the right hand, having it at its lowest position or a little to the right of this point.

55. Push crank in as far as it will go and turn slowly clockwise until it engages the crank shaft. It will usually catch when about at its lowest position. When engaged, brace yourself firmly and pull up quickly on crank, turning it about one half revolution.

56. If after repeating this operation several times, the engine does not start, it may be found necessary to spin the motor. This means cranking for a full revolution or more. In spinning the motor, care should be taken to always start with an up pull so as to gain momentum for the down thrust and so reduce the danger of a kick back to a minimum.

57. After the engine starts, advance the spark about two thirds and close the throttle. If the engine has been started on the battery and a magneto is used, switch immediately from the battery to magneto. Do not allow the motor to race. When running idle it should turn over at its lowest speed.

58. To Start the Car. Take your place in the driver's seat, place left foot on clutch pedal and press hard to release the clutch. Keep it disengaged while with the right hand the emergency brake is released and gear lever is shifted from neutral to the first speed notch.

59. Then with the right foot press the accelerator pedal gently until the motor speed is increased a little and at the same time with the left foot allow the clutch pedal to come back until the clutch starts to engage and the car begins to move.

60. From this point decrease the pressure on the pedal very gradually until the clutch is fully engaged, at the same time listening to the engine to see that it doesn't slow down sufficiently to stall.

61. If it shows signs of stalling, press accelerator pedal a little more to increase the speed, at the same time keeping a slightly greater pressure on the clutch pedal. Stalling the motor is the result of feeding too little gas with the accelerator or of not keeping pressure on the clutch pedal during the time the clutch is engaging.

62. The jerking of the car comes from feeding too much gas and engaging the clutch too suddenly. Both of these faults may be overcome by listening to the speed of the engine and keeping it right through the proper use of the accelerator pedal, and by releasing the pressure of the foot from the clutch pedal very gradually from the time it starts to engage until it is fully engaged.

63. It is impossible to become a good driver until the ear learns to judge the speed of the motor by its sound and the left foot learns to engage the clutch gradually. When the clutch has become fully engaged, press accelerator pedal slightly to speed up the machine.

64. As soon as it has attained fair momentum, release the clutch and at the same time let up on the accelerator pedal. Change gear lever quickly until you feel it take hold and then gradually at the same time pressing slightly on the accelerator pedal.

65. When the clutch pedal is pushed out the accelerator pedal should **be released. When the clutch pedal is in, the accelerator pedal should be pressed slightly.** Change from second to third and from third to fourth if your speeds are employed, always releasing clutch when gear is shifted, and always accelerating slightly while the clutch is being engaged.

66. Do not forget that the clutch is released when the clutch pedal is pushed out, and that it is engaged when the pedal is allowed to come back. Run on high-speed gear as much as possible, and when it is necessary to drive more slowly, release the clutch and apply the brake gently until the car is brought to the desired speed.

67. Then if the speed of the machine is low enough to warrant it, release the brake and with the clutch still disengaged, change from the high to the next lower speed notch and let in the clutch.

68. If the car has lost much momentum it may be necessary to change to the lowest gear before letting in the clutch, otherwise the engine may be stalled. Do not drive too close to

the other vehicles or objects before releasing the clutch and applying the brakes, as the brakes may not hold as well as you think and you may not be able to operate them correctly when in close quarters.

69. If while the machine is standing it is found impossible to move the gear lever from neutral to first or reverse, leave the lever in neutral, allow the clutch to engage slightly, then release it quickly and shift lever to desired notch.

QUESTIONS

51. Give position of gear shifting lever, emergency brake, spark and throttle levers when preparing to start motor.
52. If motor naturally starts hard, what should be done?
54. Give method of cranking engine by hand.
55. What precautions should be taken?
57. When engine starts, what should be done?
58. Give position of clutch pedal, accelerator pedal, and running brake pedal.
59. Describe method of starting car.
61. If engine shows signs of stalling, what should be done? Why?
62. What will cause jerking of the car?
63. How would you overcome jerking of the car?
65. What should be done when changing gears?
66. What is the position of the clutch pedal when clutch is released?
68. What precautions should be taken when driving car close to other vehicles?

70. To Stop the Car. Select a lamp post, tree, or other object along the curb and when still some distance from it, disengage the clutch and apply the brake gently, and get the car under control so that you can if you wish stop ten feet before the object is reached.

71. Then release the brake pressure slightly, allow the car to drift to the object, stopping with the rear directly opposite the object and the car close enough to the curb to allow passengers to alight on the sidewalk.

72. Shift gears to neutral, apply emergency brake and allow clutch to engage. Be careful that the tires do not scrape along the curb, as this is very damaging. The brake should be applied so that the car is not brought up with a jerk. This can be accomplished easily with a little practice, as can also starting of the car. Remember that you are driving for the comfort of the passengers, and they can feel the jerks and jars much more than you.

73. To Reverse the Car. Bring it to a standstill first, then with the clutch released place the gear lever in the reverse notch. Allow the clutch to engage gently with the left hand only on the steering wheel, look backward and gauge the direction by the rear end of the car.

74. Do not attempt to steer by watching the front wheels; always look to the rear when going backward, to make sure the way is clear.

75. Turning in Narrow Streets. With the car going slowly, first look back to see that there is no other vehicle coming and then turn the wheels sharply to the left as far as possible. When within five feet or more or less, depending upon the speed of the car, of the left hand curb, release the clutch and apply the brake gently, at the same time turning the steering wheel quickly to the right.

76. Stop turning the wheel when the car is brought to a standstill. With the clutch still released and the brake on, shift to the reverse gear. Then release the brake, accelerate slightly, let the clutch in carefully, and when the car starts to move continue turning the wheel to the right or clockwise.

77. This will point the car in the opposite direction. When going backward, look toward the back of the car and also up and down the street to see that no other vehicle is approaching. After the car has traveled back a sufficient distance, release the clutch, take

foot off of accelerator pedal and apply brake, at the same time turning steering wheel to the left until the car stops.

78. Then with the clutch still released and the brake still on, shift from reverse gear to first speed gear. Take right foot from brake pedal and accelerate slightly, allowing the clutch to engaged gradually, and as soon as the car starts to move, continue turning steering wheel to the left until the car goes straight ahead. Do not turn the steering wheel while the car is standing. Start to turn when the car begins to move. Do not allow tires to strike curb.

79. Turning Corners. Before turning a corner, hold out the hand so that any driver behind you may see it, and also look back to make sure that he does see it. If another vehicle is close behind you or if there is one in front coming toward you, slow up your car and wait until it has passed before turning. When turning a corner to the right keep as close to the curb as possible, so that the car will be on the righthand side when you get into the side street.

80. When turning to the left, go past the center of the street into which you are traveling and then turn sharply, so that you will be on the right side of the road. Do not cut close to the left curbs. Always go around a corner at a low enough speed to make the use of the second speed gear necessary and reduce speed so that the gear shifting must be done before starting to turn, not after, as this gives better control of the car.

81. Turning corners at a high rate of speed puts a great strain on the tires and causes them to wear excessively. It is also uncomfortable for the passengers. Use both hands on the steering wheel, and if the car is found to be going too fast, check it by releasing the clutch and applying the brake slightly. Do not shift gears before slowing the car. The idea is to slow the car sufficiently to make shifting to a lower gear necessary.

QUESTIONS

70. What should be done first when stopping the car?
71. What precaution should be taken when stopping along a curb?
72. How should brake be applied?
73. Give operations necessary to back up a car.
75. Explain method of turning in narrow streets.
79. Give method of turning corners.

82. Climbing Hills. When approaching a hill accelerate and advance the spark, as speeding up the motor makes it more powerful, and adding momentum to the car will often carry it over hills that would need an intermediate speed gear if an attempt is made to climb them slowly. As the hill is reached open throttle fully.

83. If the engine begins to feel the grade and labors or knocks, retard the spark until the knocking or laboring ceases. If the hill is a very steep one, as soon as the engine begins to lose speed, release the clutch, remove pressure from accelerator and, without applying the brake, shift to a lower speed gear.

84. Let clutch in quickly and at the same time open accelerator wide. It will then probably be found that the spark can be advanced without causing the engine to knock. On some hills it may be found necessary to shift to the first speed gear, but this should not be done unless the engine will not pull the car on a higher gear.

85. When gears are shifted on a hill the change must be made quickly and the clutch let in immediately, as slow work will allow the car to lose momentum, and then when the clutch is engaged the engine will stall. If the engine stalls, put on the emergency brake and put gear lever in neutral notch. It will be well to place a stone or block back of the rear wheels before cranking the motor as the vibration of the engine may jar the emergency lever loose.

86. In starting again, release the clutch, put lever in first speed gear, accelerate strongly, release the emergency brake and at the same time let in the clutch. This must be done quickly, otherwise the car will start to back down the hill.

87. With some cars it may be found easier when starting from a standstill on a steep

hill to apply the foot brake, release the emergency brake, engage the clutch while the foot brake is released gradually, at the same time feeding gas to the engine with the hand throttle. Do not attempt to climb steep hills until you have thoroughly mastered shifting gears on the level.

88. Descending Hills. When descending slight grades throw off the ignition switch and leave the gear lever in high speed with the clutch engaged. This will cause the engine to act as a slight brake and if necessary the running brake may be operated in connection with it. There is no harm in applying the brake under these conditions with the clutch engaged, because switching off the ignition causes the engine to stop giving you power.

89. When a very steep grade is encountered, before attempting to descend it, stop the car and shift to second or first speed gear. The lower the gear used the greater will be the breaking power, and when first speed is used it is almost impossible for the car to get beyond control.

90. The ignition may be switched off or on as the occasion requires. Switching it off gives greater braking power. The clutch must be left engaged, and the brakes may be used to help. It is well to use first one brake and then the other in descending long grades, as too long an application of one will cause it to heat and burn the friction material.

91. Do not wait until you are half way down the hill before finding out that it is too steep for the brakes to hold the car. Make up your mind before starting to descend and shift to first gear if necessary.

92. Do not allow the brakes to get in such condition that they will not hold to the best of their ability. Never descend the hill at a high rate of speed, no matter how safe it looks. Brakes do not hold so well when the car is going fast as they do when it is moving slowly, nor will they stop a car as quickly going down a grade as they will going up.

QUESTIONS

82. Give best method of climbing a hill.
83. Give positions of spark and throttle.
84. How would you shift gears on a hill?
88. Give best method of descending a hill.
89. Give best use of brakes when descending a hill.
90. What precaution should be taken when descending a hill?

94. Driving in Congested Streets. Procure a copy of the rules of the road of the city in which you are driving and obey them. Keep to the righthand curb unless it is lined with standing vehicles, in which case you keep close to them. In overtaking another vehicle, pass it on its left. In passing a vehicle coming in the opposite direction go to the right of it.

95. When stopping, hold your hand out at the side of the car to warn the man who may be behind you. Do not at any time slow down or stop without holding out your hand and looking back to make sure that it is seen. Pedestrians have the right of way at crossings, but you may warn them of your approach by blowing the horn.

96. However, do not make a nuisance of yourself by using it more than necessary. When traveling in a side street, upon coming to a main thoroughfare, slow up so that you can stop quickly, as vehicles on these streets have the right of way. When on a main thoroughfare it is not necessary to slow up at any cross street.

97. Watch the traffic policeman and when one holds up his hand, stop, first holding out your hand to warn anyone behind you. Remain standing until the policeman motions you to proceed. In some places the policemen use whistles instead of motions, and the signals used by them should be learned.

98. Whenever it is necessary to reduce the speed of the car considerable, release the clutch and apply the brake. When the car is going slow enough, shift to a lower speed gear to prevent stalling the motor when the clutch is let in. When it is found necessary to keep

behind a slow-moving vehicle, shift to a speed so low that it will not be necessary to slip the clutch.

99. If it is desirable to go slower than first speed gear, however, the clutch may be slipped by keeping a slight pressure on the clutch pedal. A great variation in speed may be obtained when in any gear by the proper manipulation of the spark and throttle levers.

100. Do not attempt to keep pace with other vehicles until you are an experienced driver. When in close quarters, perform every operation slowly, and a move made slowly but surely will probably take less time than a move made incorrectly. There is no occasion for getting excited, as it is safe to assume that every other vehicle is under perfect control.

101. Learn to shift gears without looking at the lever. Because you will need your eyes to watch the road. Sit straight in the seat; do not get hunched over the steering wheel, as this indicates a novice. Always drive into the garage on the first speed gear.

102. Washing the Car. The car should be washed immediately upon coming into the garage, before the mud has had time to dry. Do not scour off the mud as this scratches the varnish. Use the hose with a slow stream until the mud is well loosened and then finish by soaking (not rubbing) off with a sponge well wet with water.

103. Where a hose is not procurable the mud may be loosened with a wet sponge and then washed off entirely by throwing pails of water on it. Be careful that water does not go through the radiator or any other opening and get on the engine, as this is likely to short-circuit the magneto or spark plugs and prevent the motor from running.

104. If there is grease on the car, soap must be used to remove it. Castile soap is best for this purpose. However, do not apply the soap itself to the car, but make suds in luke-warm water.

105. After all mud and grease has been removed, wipe dry with chamois skin. Wash and dry the body before the running gear, and be careful that no grease is collected on chamois from wheel bearings and steering arm joints.

QUESTIONS

94. What precautions should be taken when driving in congested streets?
95. When should horn be used?
96. Give some signals of traffic police and how to obey them.
102. Give method of washing a car.
103. How should car be washed to prevent scratching paint?
104. Give method of drying and polishing car.

106. Cautions. Don't twist the steering wheel when the car is standing. Corners should be turned at a slow speed to save wear on tires. The brakes should not be applied with too much force except in an emergency, as it is hard on tires and the machine in general. Don't let the motor labor or knock when ascending hills.

107. When going down long hills use one set of brakes and then the other. Shift to first speed gear before descending steep hills. Change from first speed to reverse and from reverse to first only when the car is standing. Be very careful of skidding on wet pavements. Put non-skid chains on for wet or icy roads. Always start and stop the car without a jerk.

108. This constitutes good driving. Don't forget to see that the license pad is attached before leaving the garage. Inspect oil, gasoline, and water tanks before making a trip, and see that the necessary tools and extra tires are in the car.

109. Don't let the car stand with the motor stopped in the winter time, unless the radiator is filled with anti-freezing solution. Look the car over thoroughly after each run.

110. The records of the examination held at the school show that there are a few points of driving which a large majority of the students do not entirely master. This is not due to lack of instruction in the subjects, but is rather the result of poor memory or insufficient practice.

111. Failure to perform these operations perfectly does not necessarily mean that the student is not a safe driver, but it does show that he needs more practice before being rated as an expert.

112. If you want to be a little better than the average driver, keep in mind the following points, go back and read them over again in this booklet, think about them when driving the car, and try your best to master them.

113. When about to turn a corner, or turn in a street, or in fact whenever swerving from a straight line, look back to see if it is safe to make the turn and hold out your hand to signal what you intend to do.

114. Make sure that the spark is retarded, the gear lever is in neutral, switch on, and other levers in their proper positions before cranking the engine.

115. When the car has been slowed down to a very low speed for any reason, shift to a lower gear; don't try to pick up speed on high gear. Don't shift to a lower gear until the car speed has been reduced sufficiently.

116. In New York City traffic traveling north and south has the right of way; therefore, when crossing an avenue, go slowly and make sure you will not cut off vehicles on the avenue.

117. When starting the car, allow the clutch pedal to come back until the clutch begins to engage, then keep enough pressure on the pedal to allow it to become fully engaged very gradually.

118. Letting the clutch engage all at once makes the car jump or the engine stall, and observers smile knowingly. In this connection you should listen to the engine and operate the clutch and accelerator so that the engine is not raced or stalled.

SECTION 3

THE GAS ENGINE FROM THE IGNITION POINT OF VIEW

The Gas Engine From the Ignition Point of View

1. The Cycle. Two or Four Cycle Engines. Gas engines are divided into two classes in regard to the succession of the events which take place in the cylinders. These two classes are: The two-cycle and the four-cycle engine.

2. By the name cycle is meant one complete rotation of events which takes place over and over in an engine cylinder while the engine is running. A cycle consists of four events: an intake, a compression, an expansion, and an exhaust. A four-cycle engine, which is the class of engine almost universally used in Automobile work, is one which makes one stroke for each event.

3. Beginning with the intake or suction stroke, when the charge of gasoline vapor and air is drawn into the cylinder through the intake valve, we next have the compression stroke, during which the charge is being compressed. Following the compression stroke is the working or power stroke, when the explosion takes place. Then we have the exhaust stroke, during which the piston forces the burned gases out of the cylinder through the exhaust valve.

4. This cycle of events takes place over and over in each cylinder, regardless of the number of cylinders, the only difference being the time of the events in the different cylinders, no two cylinders having the same event taking place in them at the same time.

5. In the two-cycle engine the cycle consists of the same four events as in the four-cycle, but in this case only two strokes are made per cycle, and therefore more than one event is taking place in the cylinder at once. On account of the very limited use of the two-cycle engine, space will not be taken up with its description in this work.

6. Carburetion. By carburetion is meant the mixing of gasoline vapor and air. Gasoline is not inflammable, but a mixture of gasoline vapor and air is very inflammable; in fact, combustion takes place so rapidly with this mixture that it is called an explosion. The energy produced by the explosion resulting when a mixture of gasoline vapor and air is ignited is made use of in driving a gasoline engine.

7. In order to get the best results, the mixture should be of the proper proportions of air and gasoline vapor. A mixture of proper proportions will ignite immediately and the combustion will be complete, whereas in case of a too lean mixture, or one having too small a proportion of gasoline, the expansion will be slow, and in case of a too rich mixture, or one in which the proportion of gasoline is too great, expansion will also be slow and incomplete, as will be indicated by black smoke in exhaust.

8. A carburetor, besides providing a mixing chamber for mixing the gasoline vapor and air, automatically controls the amount of each, so that a proper mixture is provided for different speeds and loads; that is, if it is properly adjusted.

9. The carburetor is attached to the intake manifold of the engine, so that the suction from the cylinder on a suction stroke when the intake valve is open draws a current of air through the mixing chamber of the carburetor. A small pipe, called the spray nozzle, projects into this mixing chamber, so that the air rushing past the opening in the spray nozzle creates a suction and the gasoline is drawn out in the form of a spray.

·10. This breaking up of the gasoline into a spray causes it to vaporize and mix with the air on its way into the cylinder. The amount of air that may flow through the carburetor and the quantity of gasoline that may flow out of the spray nozzle are adjustable, so that the proper proportion of gasoline and air may be maintained.

11. A float, sometimes composed of well varnished cork and sometimes of sheet metal, with an air space inside, is provided for automatically regulating the flow of gasoline into the carburetor. The pipe from the gasoline tank enters the float chamber and the flow of gasoline into this chamber is regulated by a needle valve.

12. This needle valve is called the float valve, it being connected to and controlled by the float. The float valve mechanism is adjusted so that when the engine is not running the gasoline level will not quite reach the top of the spray nozzle or jet, but may be drawn out by the suction of the passing air current when the engine is running. In Fig. 1 is shown a simple diagram of the carburetor.

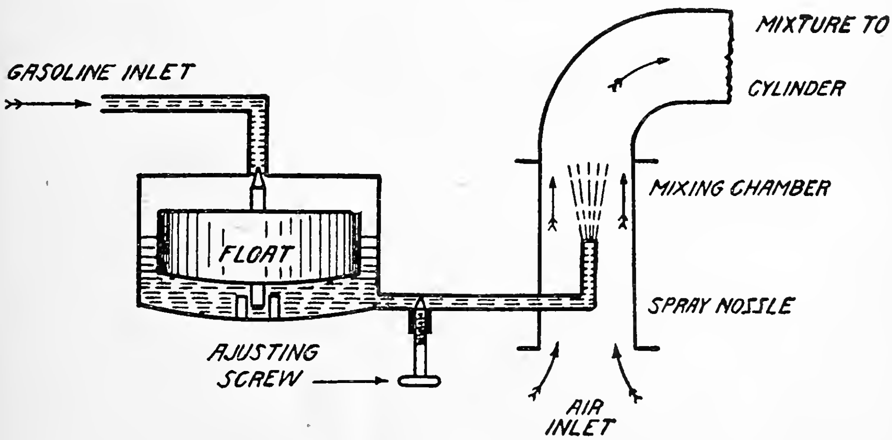


Fig. 1

13. The air is drawn through the carburetor on the suction stroke, enters through the air intake, and passes around the spray nozzle, drawing gasoline with it. The level of the gasoline in the float chamber then drops and the float also drops, opening the float valve and allowing more gasoline to enter the float chamber.

14. At this time the inlet valve to the cylinder must be open to permit the gas to be drawn into the cylinder, which it is if the piston is on the suction or intake stroke, but on no other stroke.

15. A gasoline needle valve is provided in the gasoline passage from the float chamber to the spray nozzle or in the spray nozzle itself, for adjusting the amount of gasoline leaving the nozzle.

16. A Throttle Valve, usually placed in the passage between the mixing tube and the intake manifold, is used to govern the amount of mixture entering the cylinder. The throttle valve, which is usually of the butterfly type, is connected with the throttle lever on the steering column, so that the amount of mixture can be regulated according to the power required.

17. The simple form of carburetor shown in Fig. 1 is satisfactory only for an engine which runs at a steady and constant speed, for then the rate of the air through it does not change, and the gasoline may be adjusted to correspond. The speed of an automobile engine is not steady, however, and the rate of flow of the air through the carburetor changes with the speed of the engine, increasing as the engine speed increases and decreasing as the engine speed decreases.

18. The greater the rate of flow of the air, the more gasoline will be drawn out of the spray nozzle, and the adjustment that will give a correct mixture for a low speed will give a rich mixture at high speed.

19. Carburetors for engines which run at changing speeds are therefore made so that

an extra supply of air is admitted when the air current flows so fast that it results in too rich a mixture. The extra supply of air is admitted through an auxiliary air inlet valve, as shown in Fig. 2.

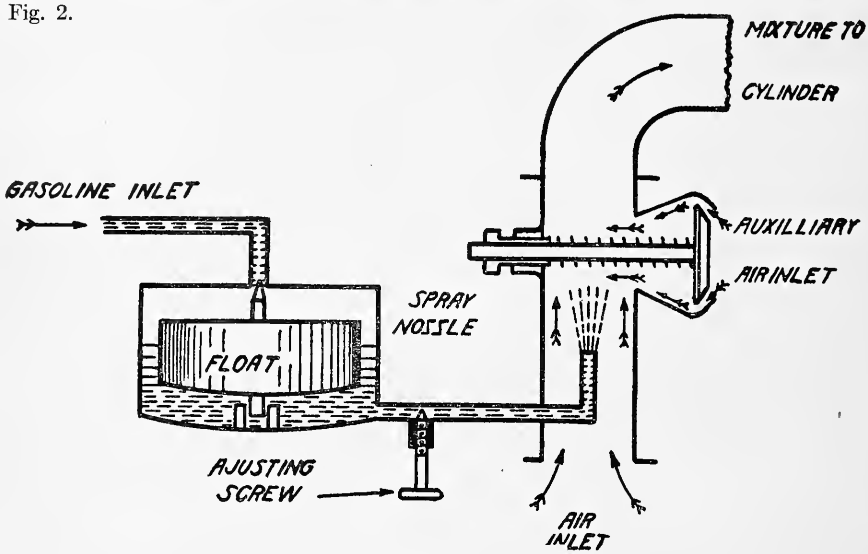


Fig. 2

20. This type is called a compensating carburetor, and is used on practically all automobiles. This auxiliary air valve is held in the closed position by a spring and is opened by the suction of the engine, so that the amount of air admitted depends upon the greater or less suction that faster or slower speeds of the engine give.

21. The gasoline adjustment needle is provided on most makes of carburetors, and is a very important part of the carburetor. The regulation of this valve is very sensitive. After the carburetor is once adjusted by regulating the auxiliary air valve and the opening of this gasoline needle adjustment valve, the slightest turn one way or the other way of this valve will make a difference in the running of the engine.

22. The type of gasoline needle valve shown in Fig. 2 is of the hand-operated type, being adjusted by hand only occasionally; other types are the mechanically-operated needle valve operated by movement of the throttle by hand through a cam arrangement, and the automatic mechanically operated needle valve, operated by action of the auxiliary air valve. These are called metering pins.

23. The main air intake on modern carburetors is usually placed below the jet or spray nozzle, at the bottom or side of the carburetor, while the auxiliary air intake is usually above the jet, and is controlled automatically by the suction of the gas going into the cylinder. The air is drawn through the auxiliary air intake valve, which operates against a spring. In some cases metal balls are used for this auxiliary air valve.

24. In some carburetors the extra air inlet is arranged so that an enlargement of the main air intake is made instead of having a separate air intake. While this works fairly well, it is not as good as if it were placed so that the extra air is admitted above the spray nozzle, so that it dilutes the mixture. The auxiliary air valve type of carburetor which is shown in Fig. 2 may be considered to-day the simplest form of carburetor which operates satisfactorily, and there are several different models now being manufactured which are based upon the principle of the auxiliary air valve only.

QUESTIONS

1. Name two classes of gas engines.
2. Explain the term Cycle.
3. Name the four strokes necessary to complete a cycle.

4. Explain the difference between two- and four-cycle engines.
6. What is carburetor?
7. What is the effect of too lean a mixture? Too rich?
8. Explain fully the function of a carburetor.
9. To what is the carburetor attached?
10. In what form does the gasoline enter the mixing chamber?
11. How is the flow of the gasoline to the mixing chamber regulated?
12. What should be the height of the gasoline in the carburetor?
13. Explain the operation of the carburetor shown in Fig. 1.
14. Would this carburetor be suitable for automobile work?
15. How is gasoline to spray nozzle regulated?
16. Give use and operation of throttle valve?
17. Explain operation of carburetor shown in Fig. 2.
18. What type of carburetor is most commonly used?
23. Give location of main and auxiliary intake.
24. Why should auxiliary intake be above spray nozzle?

25. Relation of Acceleration to Gasoline Consumption. The rapid advance of high-speed and multiple cylinder engines has demanded quicker acceleration; that is, quicker "get away" or "pick up." This calls for a sudden greater amount of gasoline or a higher percentage of gasoline to air. Quick acceleration, therefore, demands a surplus of gasoline for but a brief period, after which the normal supply will care for the engine.

26. To meet this sudden demand for gasoline the added nozzle or multiple jet has been introduced by some makers, so that when the suddenly opened throttle brings the auxiliary air valve into use the valve in turn brings more gasoline into the mixture—an added supply.

27. The Dash Pot. One method of doing this is by means of a dash pot on the auxiliary air valve stem, this dash pot performing a regular pump stroke and forcing gasoline into the mixing chamber by way of a separate nozzle as the auxiliary valve opens. When the auxiliary valve is once open, the pumping action ceases, but the nozzle remains open for a more even demand for more fuel.

28. The Metering Pin. Another method is by use of the metering pin. In some cases the throttle is connected with the needle valve and the spray nozzle, so that by a carefully computed cam action it is possible to give a sudden lift of the needle and thus give the desired fuel supply quickly. In other makes of carburetors the auxiliary air valve is connected with the needle valve in the nozzle, so that as the air valve opens there is a larger nozzle opening for the flow of gasoline. This principle is called the metering pin method.

29. Proportions of Air and Gasoline. The basis of all these methods of providing for acceleration is the accepted belief that in carburetion different mixtures of air and gasoline are needed for different engine requirements. It is no longer the belief that a uniform mixture is correct for all speeds.

30. The new rule is that the amount of gasoline fed into the air must be changed according to demands, and that if a 12 to 1 or rich mixture is best for quick acceleration; that a 15 to 1 or leaner mixture may be best for pulling with the throttle wide open, and a 17 to 1 or still leaner mixture for particularly high-speed work. Therefore a varying mixture must be supplied.

31. Example of Carburetor with Both Metering Pin and the Dash Pot. The Rayfield carburetor has two spray nozzles, each of which is provided with a needle valve or metering pin. The metering pin in the main nozzle is connected by a combination of levers with the throttle valve, and opens as the throttle opens. The metering pin in the auxiliary nozzle is actuated by the auxiliary air valve. A pumping action is also exerted on the gasoline in the auxiliary nozzle, whereby a very rich mixture is furnished for acceleration whenever the air valve is suddenly opened.

32. This is accomplished by a piston on the lower end of the air valve stem, which works in a dash pot filled with gasoline. The gasoline flows from the float chamber through a passage,

enters the dash pot above the piston and is admitted to the space below the piston by a disk valve in the piston. When the auxiliary air valve suddenly opens, forcing the piston downward, the disk valve is closed, forcing the gasoline upward through the auxiliary nozzle and spraying it into the inrushing air.

33. Only while the valve is opening does this pumping action take place, and at other times the gasoline issues through the auxiliary nozzle according to the suction of the engine. Thus the Rayfield is a combination of two pins in conjunction with the pumping function of the dash pot for quick acceleration or pick-up.

34. Priming the Carburetor. It is sometimes necessary, especially in cold weather, to prime a carburetor before starting the engine. This is accomplished in two different ways: one by depressing the float by hand, so that the float valve will open and admit a flood of gasoline to the carburetor; the other by closing a valve in the air intake, thereby causing an increased suction of gasoline. This latter is called choking the carburetor.

35. Carburetor Heating. Gasoline vaporizes more readily when warm than cold, therefore it is advisable to provide some means of furnishing heat to the carburetor. The most effective temperature seems to be about 170 degrees Fahr. This heating the mixture adds greatly to economy of fuel by more thorough vaporization.

36. There are several methods of applying heat to the mixture, some of which are:

(a) By passing hot water from the water circulation system through the water jacket of the carburetor or intake manifold.

(b) By passing exhaust gases from the exhaust pipe through the water jacket instead of the water.

(c) By taking hot air from around the exhaust pipe and passing it through the main air intake of carburetor.

(d) By heating the mixture electrically before it passes into the cylinders. This is done by placing an electric heating coil around the carburetor.

37. Adjustment of the Carburetor. A carburetor should never be tampered with as long as it is working properly. Test for motor compression: See that there is good hot spark occurring in each cylinder at the right time and plenty of gasoline. The carburetor should be the last thing to touch. If the motor refuses to start, first flood or prime the carburetor; if gasoline does not appear, look for a leak or obstruction in the gasoline feed pipe, a closed shut-off valve, a dirty strainer, or clogged spray nozzle.

38. If a carburetor floods or leaks gasoline when the car is standing, look for an obstruction under the float valve, a leak at one of the connections, or a leaking float. If the motor starts, but a popping noise occurs in the carburetor when the throttle is suddenly opened, it indicates a lean mixture. Open the gasoline needle valve slightly. If the motor runs sluggishly, with a black smoke at the exhaust, it indicates too rich a mixture. Close the needle valve slightly. If the motor refuses to idle properly, or lacks "ginger" or "pep" at high speed, close the air adjustment slightly, and if not already too rich at low speed, the gasoline may also be opened slightly by turning to the left.

39. Parts to Adjust. The three principal parts of a carburetor used for making adjustments are: the auxiliary valve, the gasoline needle valve, and the float mechanism.

40. Float Adjustment. When a carburetor drips it usually indicates that the float or float valve mechanism is out of adjustment or the float is leaking, so that the gasoline reaches too high a level, resulting in an overflow at the spray nozzle. The adjustments for this are: see that the float valve seats properly, that the mechanism is properly adjusted to bring the gasoline level about 1/8" or less below the top of nozzle, and if float leaks to repair it.

41. Auxiliary Air Valve Adjustment. The needle valve should be set for slowest running, with the air valve held firmly against its seat, and then the spring adjustment should be backed off until the slightest further increase in throttle opening causes the valve to leave its seat. The adjustment from here on is that of spring strength. Too strong a spring will cause too rich a mixture, because the valve will be more difficult to open by suction.

42. Too weak a spring will give too much air or too lean a mixture. The hand air ad-

justment is very popular. This consists of a valve in the air intake operated by hand from the steering column. By the use of this hand adjustment more air can be admitted as the engine heats up and requires a leaner mixture.

QUESTIONS

25. What is meant by Acceleration?
26. Give operation of the Dash Pot.
27. Explain the operation of Metering Pin method.
28. Should the proportion of gasoline and air always be the same?
29. Give example showing proportion.
30. Explain operation of carburetor described in paragraphs 31, 32, and 33.
34. What is meant by priming a Carburetor? Why necessary?
35. What effect does heating have on the operation of Carburetor?
36. Give four methods of heating.
37. What would cause carburetor to run dry when there was plenty of gasoline in the tank?
38. What would cause carburetor to flood or leak?
39. Name parts of carburetor to adjust.
40. Give proper adjustment of the float.
41. Give proper adjustment of the auxiliary air valve.
42. Explain method of adjusting average carburetor.

43. Adjusting the Average Carburetor. Carburetors are usually adjusted to the best advantage when the engine has been run and all parts are warmed up. Even if the carburetor is properly adjusted an engine will not hit just right when starting, especially in cold weather; it will miss and not run evenly or smoothly until it has run a few minutes and is warmed up.

44. For the average carburetor having an auxiliary air valve and a needle valve adjustment, the following rules for adjusting will apply:

First. Run the engine at what will be nearly maximum speed in ordinary use, with the throttle well open and the spark rather late. This speed of course will be considerably less than the maximum speed of the engine when running idle.

Second. Then turn the main gasoline adjustment until the mixture is so weak there is a popping in the carburetor.

Third. Note this position and then turn the adjustment till so much gas is fed that the engine chokes and threatens to stop.

Fourth. Set the adjustment half way between these two points, which will be very close to the correct position. Turn the adjustment first in one direction and then in the other until the point is found where the engine seems to run the fastest and smoothest.

Fifth. Gently and gradually cover the auxiliary air inlet of the carburetor by placing the hand over it, if necessary, in order to exclude the air. If the engine slows down, the spring should be weakened, since not enough air is allowed to enter the carburetor.

Sixth. Next try opening the air inlet slowly and gradually by pushing the poppet off its seat with the finger or the end of a pencil. If the engine speeds up there was not enough air and the spring should be loosened, while if it slows down the mixture is correct or a little too lean, according to the degree to which the speed is affected. If it is found to be too lean the spring needs tightening.

Seventh. After the air inlet has been adjusted, open the throttle again and adjust at high speed, as the adjustment may now need to be altered.

VALVES AND VALVE TIMING

45. There are at least two valves for each cylinder in all four-cycle gasoline engines: an inlet valve and an exhaust valve. Some four-cycle engines have four valves for each cylinder, two inlet valves and two exhaust.

46. There are three types of the valves in use—the poppet, sleeve, and rotary. The poppet type is the one in general use, and we will confine ourselves to a discussion of it only.

47. **The Inlet Valve** admits fresh gas to the cylinder, and since fresh gas is taken into the cylinder during only one stroke of every four, or, in other words, during one stroke for every two revolutions of the crank shaft, the inlet valve is open during only one stroke in every four.

48. **The Exhaust Valve** permits the burned and useless gases to escape, and it too must be open during one stroke of every four.

49. Mechanically operated valves are opened and held open by means of cams on a shaft which is geared to the engine crank shaft. This shaft is called the cam shaft, and gears which drive it are called timing gears. The exhaust valves are always mechanically operated, except on some of the old engines.

50. The valves of a gasoline engine always open inwardly, so that the pressure from the power and compression strokes tends to keep them firmly on their seats.

51. Types of Engines using Poppet Valves are the "T" head engine, the "L" head engine, and the overhead valve or "valve in the head" engine.

52. In the "T" head engine two pockets are provided at the head of the cylinder, one on each side, with the inlet valve in one pocket and the exhaust in the other pocket. There are two cam shafts in this type of engine, one on one side for operating the intake valves, and one on the other side for operating the exhaust valves.

53. In the "L" head engine there is only one pocket, with both the exhaust and inlet valves placed in it. The cams for operating the intake as well as those for operating the exhaust valves are on one cam shaft.

54. In case of the valve in the head engine there are no pockets, and both valves are placed in the cylinder head, one cam shaft being provided, as in the "L" head engine.

55. Different methods for operating Poppet Valves are: (1) by a plunger or tapper; (2) by an overhead rocker arm; (3) by an overhead cam.

56. The valves in "T" and "L" head engines are operated by a plunger or tapper which comes in contact with the valve stem and raises the valve. The tappet is actuated by the cam on the cam shaft, and is adjustable as to length in order to take care of wear.

57. Overhead valves are operated in some cases by tappets through a rocker arm which extends over the top of the cylinder, and in other cases by an overhead cam shaft which extends along the top of the cylinders.

58. **Valve Construction.** There are three different valve constructions: (1) the "side or pocket type"; (2) the "cage" type; (3) "the detachable" cylinder head type.

59. The "side or pocket type" valve is always placed on the side, and can be removed from its seat by lifting it through the valve cap opening, but it must be ground in its seat in the cylinder.

60. The "Cage" type is made detachable, so that it can be screwed into or out of the cylinder head. It can be removed with its valve seat for grinding or repairs. The "detachable cylinder head" type: The head of the cylinder must be removed in order to grind or remove the valve.

61. **Valve Timing.** Since the valves are open during only one stroke out of every four, or one stroke during two revolutions of the crank shaft, and since the cams open the valves, it is evident that the cam shaft must be driven at a speed equal to half crank shaft speed, or, in other words, must make one revolution to two of the crank shaft. It is also evident that the cams must be placed on the same shaft in such a position that each valve is opened at the proper time and held open for the proper length of time. Valve clearance must be made before setting the time of valves.

62. Valve Clearance means the distance between the end of the valve stem and the end of tappet when the valve is seated. When an engine becomes noisy and a clicking sound is heard, the trouble is likely to be that the valves and valve stems have worn considerably, or the adjustment nut on end of tappet has become loose.

63. This adjustment can usually be made by screwing up the adjustment screw and then locking the position with lock nut. Ordinarily the clearance is from .003″ to .005″.

64. After valves have just been ground, give, say 1-64″ clearance; then after car has been run about 20 miles and engine is well warmed up, give the final adjustment. If, when final adjustment is made an ordinary sheet of paper can be easily passed between valve stem and tappet, it should be about right.

65. If valves become pitted and leak, they need grinding; and if they are warped or shoulders form in the seat, then the valve and seat should be refaced.

66. **Valve Opening and Closing.** The cams are so placed on the cam shaft that the valves are opened at the correct time, held open the proper length of time, and closed at the proper time.

67. **Inlet Valve Opening.** If one of the cams raises an inlet valve just as the piston is starting down on the suction stroke, a charge of gas will be drawn into the cylinder as long as the piston is on the suction stroke and the valve is open. The valve should therefore open in time to give the piston a chance to draw in a cylinder full of gas.

68. If the valves were to open late in the stroke a full cylinder of gas would not be drawn in, and the power of the motor would be less than what it should be. The inlet valve timing gear is used for timing the inlet valve to open at the right time, this being done by meshing the gears at the right place.

69. The practice is to allow the piston to descend about an eighth of an inch in the cylinder on the suction stroke before the inlet valve opens, so as to reduce the pressure and create, if anything, a suction before admitting the gas.

70. **Inlet Valve Closing.** It is almost a universal practice to leave the inlet valve open until the piston has not merely reached the bottom of the stroke, but has actually traveled slightly up again on the compression stroke. It would seem that part of the gas would be forced out of the cylinder, but this is not the case, as the high speed at which the piston is traveling causes the suction to continue for a short time on the compression stroke.

71. This will of course vary with the speed of the engine, so that a certain valve setting will not be correct for all speeds, since if the inlet valve is closed at the correct time for slow speed it will close too early for higher speeds and less gas will be drawn in than would be with correct setting.

72. However there is an average speed for all engines, and the valves are set to it accordingly. This average speed on most engines is approximately 1,000 revolutions per minute.

73. **Exhaust Valve Opening.** The exhaust valve must open considerably before the piston reaches the end of the expansion stroke, and although this may waste some of the force of the explosion, it is amply compensated for by the freedom afforded the piston in connecting the exhaust stroke.

74. It would be wrong to keep the exhaust valve closed up to the very moment when the piston is about to move upward, for on commencing the exhaust stroke, the piston would be confronted for an instant with the force that had just driven it down, and until the valve was wide open it would be considerably impeded on "its journey."

75. The exhaust valve is usually opened when the piston has moved through about seven-eighths of the power stroke; that is, about half an inch from bottom of dead center. Exhaust valves opening too early, however, cause pounding and clatter.

76. **Exhaust Valve Closing.** The exhaust valve must not close before the end of the exhaust stroke, on account of the gas which remains in the cylinder head being slightly under pressure at the end of the stroke. The valve is often allowed to remain open until the piston has moved about 1-20″ down on the suction stroke, so as to give full opportunity for as much exhaust gas to escape as possible.

77. **Periods of Time Valves are Open.** Valves are timed in degrees; that is, one revolution of the crank or flywheel can be divided up into 360 degrees the same as a circle; then we can speak of a whole revolution of crank shaft as 360 degrees, a half revolution as 180 degrees, and one-quarter of a resolution as 90 degrees. It is evident, then, that one stroke of the piston will represent 180 degrees on the flywheel, and two strokes will represent 360 degrees.

78. In this manner we can speak of piston travel and the relation of valve movements or time of opening and closing of valves to piston travel in degrees, and if we wish can mark the positions of top and bottom dead centers on the flywheel and the time of valve opening in degrees as referred to these markings.

79. The time the valves are usually held open and time of opening and closing are shown in Fig. 3.

QUESTIONS

45. Give number and names of valves employed in four-cycle engines.
46. Give three kinds of valves.
47. What kind is best?
48. Give use and operation of intake and exhaust valves.
49. What causes the valves to open and close?
50. Why must the valves open inwardly?
51. Give types of engines using Poppet valves.
52. Where are valves located in "T" head engines?
53. Where are valves located in "L" head engines?
55. Give three methods of operating poppet valves.
56. How are valves operated in "T" and "L" head engines?
58. Name three different kinds of valve construction.
59. Give location of each.
61. Why is valve timing necessary?
62. What is meant by valve clearance? Why necessary?
63. Give average valve clearance.
66. What is meant by valve opening and closing?
67. When should the intake valve open?
70. When should the intake valve close?
74. When should the exhaust valve open?
76. When should the exhaust valve close?
79. Describe valve opening, time held open, and valve closing, as shown in Fig. 3.

80. In practice the inlet valve is seldom opened on top of dead center, but from five to fifteen degrees later in the stroke, as shown in Fig. 3A. It is also customary to have the inlet to close from 5 to 28 degrees after the bottom, Fig. 3B; the exhaust valve to open from 40 to 50 degrees before the bottom, Fig. 3C, and the exhaust valve to close from 5 to 10 degrees after top of dead center, Fig. 3D.

81. The time that a valve is held open depends upon the length of the nose of the cam. The nose of the inlet cam is usually shorter on its length of face than the exhaust cam, on account of the exhaust cam holding the valve open longer than the inlet cam holds the inlet valve open.

82. Valve Timing Position. The position of the crank shaft determines the position of the piston, and the position of the piston determines the point where the valve is set to open or close. Therefore the cam shaft must be so placed that the cam will raise the valve when piston is at a certain position. This is accomplished by meshing the cam gear with crank shaft gear when piston is in correct position.

83. Setting Valves on a Single Cylinder Engine. Suppose the valves on a single cylinder engine are to be set with exhaust to close on dead center and inlet to open when the piston is 1/8" after top dead center on suction stroke.

84. Setting Exhaust Valve. Place piston (by turning crank shaft) on top dead center, then mesh exhaust cam gear with crank gear, so that exhaust valve is just seating.

85. Setting Inlet Valve. Move piston down 1/8" from top dead center; mesh inlet cam gear with crank shaft gear.

It will be noted that the inlet opens and suction stroke begins right after exhaust closes.

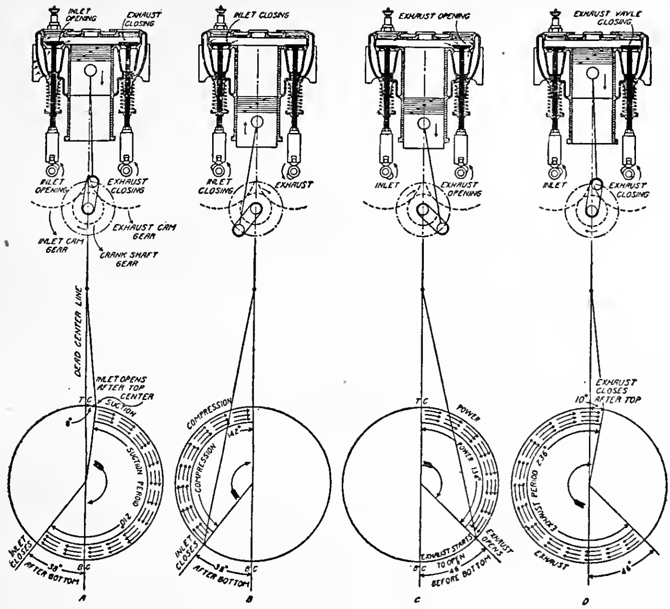


Fig. 3

Therefore the closing of the exhaust and opening of the inlet is the point to work from a single cylinder engine.

86. Setting Valves on a Multiple Cylinder Engine. Setting the valves or timing a multiple cylinder engine is identically the same operation as timing a single cylinder engine.

87. If it is a four-cylinder engine, the crank shaft is made so that pistons 1 and 4 are in line and directly opposite pistons 2 and 3, which are also in line. That is, pistons 1 and 4 will be on one dead center when pistons 2 and 3 are on the other dead center. If it is a six-cylinder engine, pistons 1 and 6 are in line and 3 and 4 are in line, also 2 and 5.

88. If cylinders are "L" type or valve-in-head type, there is only one cam shaft to set, and the timing is done from only one cylinder, usually the one next to radiator, called No. 1.

89. If cylinders are "T" type, then it will be necessary to set the inlet cam shaft separately, but it is necessary only to set valves in one cylinder, as the other cams are fastened permanently on the cam shaft, and must open and close all other valves at the correct time.

90. It is therefore not necessary to set the cams on cam shaft, but by meshing the cam gear in front of the engine with the drive gear, the position of the nose of the cam can be adjusted. The usual plan is to place piston of No. 1 cylinder at the top of its stroke and work from that point.

91. Timing by Marks on Flywheel. Usually marks appear on the circumference of the flywheel, which indicate position in which crank shaft is to be placed for correct setting of valves. A center mark is usually placed on the cylinder or elsewhere, and the marks on flywheel placed in line with it.

92. If there are no marks, then it will first be necessary to determine where you wish to set the valves.

93. Timing a "T" Head Engine. Suppose we have a "T" head four-cylinder engine, and wish to time the valves as follows: Exhaust to close 2½ degrees past upper dead center. Inlet to open 10 degrees past upper dead center.

94. In actual practice this is really all that is necessary to know, as the other points of opening and closing will be taken care of by the other cams on the cam shaft.

95. Procedure of Marking Flywheel. Place No. 1 piston exactly on top dead center. Now make a line on face of flywheel and mark it "1-4 UP," meaning pistons 1 and 4 are on upper dead center. Next measure 2½ degrees from this line to the right and make another mark on the flywheel; mark it "E C", meaning exhaust closed.

96. Now make another line 10 degrees from the dead center line to the right on flywheel; mark this "I O," meaning inlet opens. Note that you are supposed to be in the rear of the engine, facing flywheel, and engine is supposed to revolve counter-clockwise as you look at it.

97. Setting Exhaust Cam. Now turn flywheel slightly until line marked "E C" is in line with mark on cylinder. At this point piston is 2½ degrees down (measured on flywheel in direction of rotation from top). Take exhaust cam gear out of mesh with crank shaft gear; turn exhaust cam in direction of rotation (opposite of crank shaft), place exhaust cam at closing point. Mesh exhaust cam gear and exhaust valves are timed.

98. Setting Inlet Cam. Next turn flywheel to left until line "I O" is in line with center mark on cylinder. Take inlet gear out of mesh and turn inlet cam shaft in direction of rotation until it is just at the point of opening. Mesh gears and inlet valves are timed.

99. Timing Valves on "L" Head Type of Engine. Only one cam need be set when all valves are on one side or in the head of cylinders, and all cams are on one cam shaft, as is the case with "L" head and "valve-in-head" engines.

100. The usual plan is to place No. 1 piston in the position where exhaust valve is to be closed, and mesh the cam shaft gear at this point. Although it is only necessary to set the exhaust cam so the exhaust valve will close, on all "L" type engines there are other marks which are used for checking the timing.

101. As an example, the Regal four-cylinder engine, with timing scale as follows: Dead center of cylinders 1 and 4 are marked on flywheel "1-4 dead center." Intake valve opens 5 degrees past top center, marked on flywheel "1-4 I N opens." Intake valve closes 40 degrees past bottom center marked "1-4 I N closes." Exhaust valve opens 40 degrees before bottom center marked on flywheel "1-4 E X opens." Exhaust valve closes 7 degrees past top center marked on flywheel "1-4 E X closed." The same marks appear for cylinders two and three.

102. Checking the Valve Timing. The purpose of checking the valves is to see that they are opening and closing as marked on the flywheel.

103. To determine whether or not the valves are properly timed, first open the relief cocks on top or side of cylinder, then turn flywheel to the left until the line marks "1-4" is opposite the center line of the cylinder. At this point the exhaust valve in either No. 1 or No. 4 cylinders should just commence to close.

104. If you find that the exhaust valve in No. 4 cylinder is beginning to close, and you wish to check up the valve timing of No. 1 cylinder, turn the flywheel around to the left one complete revolution, until line "1-4" is again brought opposite the center line of the cylinder; then continue slowly turning the flywheel about one inch farther to the left until the line marked "7" coincides with the center line of cylinders. This is the point at which the exhaust valve in No. 1 cylinder should just seat itself or close.

105. To determine whether or not the valve is seated, see if tappet can be turned with the fingers. If the tappet turns freely the valve is seated, but if it is hard to turn this will show that the valve is still being held slightly open. If this is the case, loosen the lock nut on the tappet screw and turn the screw down until the valve just seats; then turn the lock nut down tight against the tappet.

106. To check up the timing of the inlet valve in the same cylinder, turn the flywheel to the right until the line "1-4" is in line with the center of the cylinders, and then turn the flywheel about ¾" to the left, until the line marked "5" coincides with the center line of the cylinders. At this point the inlet valve should just begin to open.

107. Turn the flywheel half a turn to the left, stopping when the line marked "4. O," just to the right of 2-3 comes in line with center of the cylinders. At this point the inlet valve should just close. To see if the exhaust valve opens at the proper time, revolve the flywheel

three-fourths of a turn to the left, and stop when the second line, "40", which is the first line to the left of the "2-3" center line, comes up in line with the center of the cylinders. This is the point where the exhaust valve in No. 1 cylinder should just begin to open. The above completes the timing of cylinder No. 1.

108. To time cylinder No. 2, turn flywheel until line marked "2-3" is in line with center of the cylinders. If the exhaust valve in the No. 2 cylinder is closed, turn the flywheel through one complete revolution until the line "2-3" is up again; the exhaust valve in No. 2 cylinder should then be just starting to close. Proceed now in the same manner as when timing the No. 1 cylinder.

109. Cylinders Nos. 1 and 4 are timed from the center line "1-4," and cylinders Nos. 2 and 3 from the line "2-3."

110. Averaging Valve Timing. There is very little difference between the average timing of the four- and the six-cylinder engines. On the six the average inlet opening is 10.7 degrees past top dead center, and closing point 35.6 degrees past bottom center. On the four, the average for inlet opening is 11.1 degrees after top center, and closing point 36.8 degrees after bottom center. The small difference would hardly be noticeable. The exhaust on the average six opens 46 degrees before bottom center, and the four 46.3. The closing point of sixes averages 7 degrees after top, and the four 7.7. Therefore there is very little difference between the four and six in this respect.

111. Timing Valves on Six-Cylinder Engines. Example: Inlet valve opens 15 degrees after top center and exhaust closes 10 degrees after top center. When the line marked "1-6" is in line with center mark on engine, pistons Nos. 1 and 6 are at their highest point or top dead center. After turning flywheel to this mark, turn flywheel to the left until the small dot mark is opposite mark on engine. This is the point 10 degrees to set exhaust valve just closing.

112. Fig. 4 shows the flywheel markings for a six-cylinder engine. The cranks in a six-cylinder engine are set in pairs, each pair being 120 degrees from the others. That is, pistons 1 and 6 are in line, so also are 2 and 5 and 3 and 4. The timing for the cylinders will then begin from the marks on flywheel 120 degrees apart, as shown in Fig. 4. The principle of timing the six is similar to that of the four.

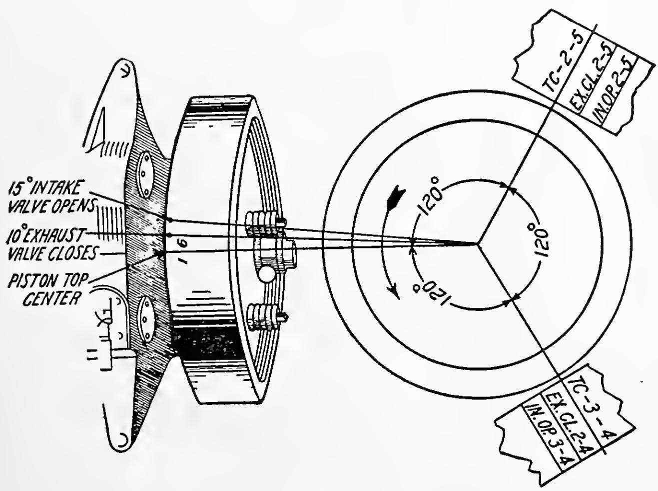


Fig. 4

113. Firing Order. The cylinders of a gasoline engine are generally numbered from the front, the one next to the radiator being No. 1. Now it would not be practical to fire the cylinders in succession 1, 2, 3, 4, etc., on account of the rocking motion which would result.

For this reason the crank shaft of a four-cylinder engine is made so that the pistons 1 and 4 are 180 degrees from pistons 2 and 3, and cranks 1 and 4 will be on top dead center when cranks 2 and 3 are on lower dead center. The firing order of a four may then be 1, 2, 4, 3, or 1, 3, 4, 2.

114. There are two kinds of six-cylinder crank shafts—left-hand and right, the difference being distinguished as follows: If, when looking at the engine from the front, cranks 1 and 6 are on top center and cranks 3 and 4 are to the right of 1 and 6, the crank shaft is then a right-handed one, whereas if they are to the left and 2 and 5 are to the right, the crank shaft is a left-handed one. The firing order of a six-cylinder engine is usually 1, 5, 3, 6, 2, 4 for a right-handed crank, and 1, 4, 2, 6, 3, 5 for a left-handed one.

115. The timing of six-cylinder valves is identical with that of the four. It is only necessary to time with the exhaust valve closing on the first cylinder on the "L" head type, with exhaust valve closing on exhaust side and inlet opening on inlet side.

116. Eight- and twelve-cylinder engines are usually built with the cylinders cast in a block in "V" shape, and are called "V" block engines. The eight is similar to two four-cylinder engines working on a regular four-cylinder crank shaft at an angle of 90 degrees. The twelve is similar to two sixes working on a regular six-crank shaft, the two sets of cylinders being set at an angle of 60 degrees with each other. The cylinders are numbered from the front, the two next to the radiator being IL (No. 1 left), and IR (No. 1 right).

117. The firing order of eights is usually 1L, 2R, 3L, 1R, 4L, 3R, 2L, 4R; and of twelve, 1R, 6L, 4R, 3L, 2R, 5L, 6R, 1L, 3R, 4L, 5R, 2L. Considering each side of a twelve-cylinder engine as a separate six-cylinder engine, the firing order would be 1, 4, 2, 6, 3, 5.

IGNITION, IGNITION TIMING

118. Time of Firing. In the regular operation of a gasoline engine, combustion should take place as a piston is on top of the compression stroke, and the charge must, therefore, be ignited an instant before the end of the compression stroke in order that the charge may have time to take fire. In case of magneto ignition, the magneto armature is so set, relative to the engine crank shaft, that the maximum voltage occurs at that instant.

119. It is, however, necessary to be able to shift the point in the cycle at which the spark occurs for different engine speeds. When the engine is cranked by hand the spark must occur after the end of compression stroke, otherwise the engine may kick back.

120. If started by some form of self-starter, it is possible to start with slightly more advance than when starting by hand, because the self-starter turns the engine faster.

121. The spark should always be fully retarded when starting.

122. Advance and Retard Spark. The meaning of advance of spark is to cause the spark to occur earlier, before piston is on top of compression stroke.

The meaning of retard of spark is to cause the spark to occur later in the compression stroke.

123. The exact position to advance or retard is determined by running as far advanced as possible at all times until a knock is detected, and then retard until the knock disappears. The driver will soon learn the exact position where the engine gives the greatest power.

124. Control of Spark. As the spark occurs only when the primary circuit is broken by the opening of the circuit breaker contacts, the timing of the spark can, therefore, be controlled by having these contacts open sooner or later. This is accomplished by moving the breaker by means of the timing lever which is attached to it. This movement gives a timing range of about 30 degrees.

125. The spark is fully retarded when the timing lever is pushed as far as possible in the direction of rotation of the cam, and is fully advanced when pushed in the opposite direction as far as it will go.

This is the hand method of spark control; the timing lever is connected to a control lever on the steering column which is operated by the driver.

126. Automatic Control is used on some ignition systems for automatically advancing the spark as the speed increases. Centrifugal force is employed, this being accomplished by

weight mounted on the distributor shaft, which swings out as the speed increases and turns the cam on the shaft which supports it.

127. These weights are connected by a system of levers to the cam in such a way that as they swing out the cam is moved on the shaft in the direction in which it is rotating, thus causing the spark to occur earlier in the stroke as the speed increases.

128. Relation Between Time of Spark and Time of Combustion. The combustion should take place as the piston is on top of the compression stroke (Fig. 5), because at that point the gas drawn into the cylinder has been forced up into the head of the cylinder, and is at the point of greatest compression, hence more force is exerted on the piston if the explosion occurs at this point.

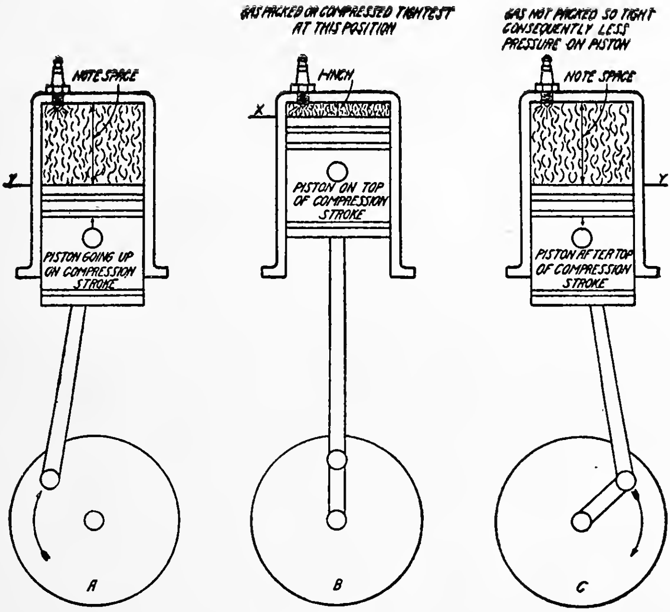


Fig. 5 (a) (b) (c)

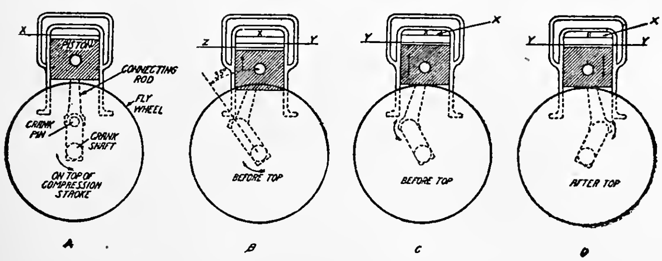


Fig. 6 (a) (b) (c) (d)

129. If combustion occurs before or after the piston has reached the top of compression stroke (Fig. 5), loss of power will be the result.

130. If combustion occurs before or after the piston has reached the top of compression stroke, the compression is not as great as if it occurred at top of stroke. If the explosion occurs before the top of stroke, the force will act against the pistons' travel and cause knocking and loss of power.

131. For example: Fig. 5A piston is going up on compression stroke, compressing the gas which was drawn in at the previous suction stroke. At the point where the piston is shown in Fig. 5A the gas is but slightly compressed.

132. Fig. 5B. The piston has now reached the top of compression stroke and the gas is well compressed into head of cylinder. It is easily seen that if the combustion took place at this time the force against the piston would be greater than if it took place earlier in the stroke, as in Fig. 5A, or later, as in Fig. 5C.

133. Time for Spark to Occur. There is a difference in time between the time the spark is made at the spark plug and the time the combustion of the gas actually takes place, this space of time being required for the gas to ignite and expand. Therefore, since we desire that full expansion occur at the highest point of compression, we must figure out just how far in advance of the top of the compression stroke the spark must be set to occur in order to accomplish this.

134. Relation of Speed to Time of Spark. When the engine is running slow, the spark must be set (retarded) to occur later or nearer the top of compression stroke, than if the engine were running fast.

135. Suppose engine were running at 500 revolutions per minute. Taking (x) Fig. 6C as top of compression stroke, the distance to set the spark would be at, say (y) Fig. 6C in order to give the combustion time to take place when the piston is on top of compression stroke.

136. Now if the spark was set to occur at (Y) Fig. 6C and the speed was increased to 1,000 revolutions per minute, then the piston would go to the top of compression stroke at (X) Fig. 6D and pass over and down to (Y) on the other side, or down part way on the power stroke, before the process of expansion was completed. The result would be a loss of power during the piston down travel between the points (X) and (Y), Fig. 6D, the full force of the expansion not being exerted on the piston until the latter point (Y) was reached.

137. It will then be necessary to set the spark or advance it to a point, say (Z), Fig. 6B, which will allow of complete expansion by the time piston reached top of stroke (X).

138. Speed Relation Between Crank Shaft and Cam Shaft, also of Armature of Magneto and Distributor. On four-cylinder four-cycle engines the cam shaft turns ½ revolution while crank shaft turns 1 revolution.

139. Two revolutions of crank shaft are necessary to complete the four strokes, and four sparks, one in each cylinder, are necessary during these two revolutions of the crank shaft.

140. Therefore if the magneto or generator armature revolves but two revolutions, the same as the crank shaft, then it must make two sparks to each revolution, or one spark to each half revolution, or four sparks to two revolutions.

141. In order for the distributor to furnish two sparks during this half revolution of the armature, it will be necessary to gear it to run one-half the speed of the armature, or the same speed as the cam shaft.

142. A two-point cam is used on a magneto circuit breaker, which interrupts the primary circuit twice during a complete revolution.

143. On a six-cylinder four-cycle engine the cam shaft turns one-half times crank shaft speed. Magneto armature turns one and one-half times crank shaft speed. Distributor on magneto turns one-half crank shaft speed.

144. Two revolutions of crank shaft are necessary to complete the four strokes, just the same as in the four-cylinder engine. Six sparks are necessary for the two revolutions of the crank shaft. The distributor revolves at one-half crank shaft speed, or same as cam shaft. Therefore on a six the distributor is geared 3 to 1 of the armature, which will cause it to revolve at one-half crank shaft speed.

145. In battery ignition systems the distributor and breaker cam are driven at one-half crank shaft speed, a six-point cam being used on a six-cylinder engine and a four-point cam on a four-cylinder engine.

QUESTIONS

82. Describe proper valve timing position.
84. Give method of setting intake valves.
85. Give method of setting exhaust valves.
86. Describe method of setting valves on a multi-cylinder engine.
91. What do the marks on a flywheel indicate?
95. Give proper method of marking a flywheel.
97. Give exhaust valve setting.
98. Give intake valve setting.
102. Give method of valve checking or timing.
110. Give average valve timing.
112. Give method of timing valves on a six-cylinder engine.
113. Give possible firing orders of four-cylinder engines.
117. Give usual firing order of an eight-cylinder engine.
118. When should combustion take place in the cylinder of a gas engine?
119. What results if combustion takes place too soon?
120. What results if combustion takes place too late?
121. When should the charge be ignited?
122. When cranking by hand, when should the charge be ignited?
123. What is meant by advancing and retarding the spark?
124. Give best position to set spark for running.
125. When does the spark occur with the average ignition system?
126. Describe the operation of an automatic spark control.
127. Describe relation between time of spark and time of combustion.
130. Why not set the spark at a certain point and leave it there?
131. What would result if combustion took place before piston reached top dead center when cranking by hand?
136. Give relation of speed between crank shaft and cam shaft.
137. Give relation of speed between cam shaft and magneto shaft for four-cylinder engines. For six-cylinder engines.
139. Give speed of a magneto on four-, six-, and eight-cylinder engines.
140. How many sparks does a magneto produce per revolution of its armature?
145. Give speed of timer or distributor in battery ignition systems.

MAGNETO TROUBLES

1. Carbon dust, oil, or dirt in distributor.
2. Metal dust in distributor.
3. Brushes not making firm contact.
4. Worn or burnt distributor segments.
5. Collector brush or collector ring broken.
6. Distributor brush broken.
7. Oil-soaked windings.
8. Magnets weak.
9. Magnets reversed on Magneto.
10. Magnets loose on pole pieces.
11. Rubbing Armature.
12. Worn bearings.
13. Breaker points pitted.
14. Breaker points out of adjustment.
15. Defective bearings.
16. Defective condenser.
17. Magneto armature out of time with distributor.
18. Magneto loose on bracket on engine.
19. Interrupter cam worn.

20. Worn fiber block.
21. Fiber bushing in breaker arm binding.
22. Broken breaker arm spring.
23. Weak breaker arm spring.
24. Ground wire grounded.
25. Ground wire broken.
26. Dirty safety spark gap.
27. Safety spark gap too close together.
28. Spark advance lever sticks.
29. Magneto shorting—switch short-circuited.
30. Magneto shorting—switch open-circuited.
31. Loose platinum breaker point on breaker arm.
32. Excessive lubrication.
33. Water on magnets.

SPARK PLUG TROUBLES

1. Cracked insulator.
2. Oil-covered insulator.
3. Loose insulator.
4. Porous insulator.
5. Wire loose in insulator.
6. Carbon deposits on electrodes.
7. Broken gasket.
8. Gap too close.
9. Gap too wide.
10. Mica insulation oil-soaked.

CARE OF SPARK PLUGS

1. Clean with gasoline, and brush and scrape.
2. Use new gaskets occasionally—easy on plug.
3. Do not wedge carbon particles or tools between insulator and shell.
4. See that all electrodes burn white.
5. Do not drop plug.
6. Do not screw cold plug tight in hot engine.
7. A drop of oil on threads prevents sticking.
8. Insure equal plug gaps in all cylinders of engine.
9. Do not allow globules of metal to short-circuit plug gap.
10. Keep spark plug insulators dry.

IGNITION SYSTEM TROUBLES

MOTOR HARD TO START

1. Ground wire short-circuited?
2. Defective magneto (no spark at plugs).
3. Broken spark plug insulators.
4. Carbon deposits or oil between plug points.
5. Spark plug points too close or too far apart.
6. Wrong wires on plug terminals.
7. Short-circuited high tension lead.
8. Broken high tension lead.
9. Incorrect ignition timing, spark late or early.
10. Defective platinum points in breaker box.
11. Breaker points not separating.
12. Broken breaker arm spring.

13. No contact at collector brush.
14. Breaker points burned or pitted.
15. Breaker arm stuck.
16. Fiber bushing swollen.
17. Short-circuiting spring grounded.
18. Dirt or water in magneto casing.
19. Oil on breaker points.
20. Distributor filled with carbon dust and oil.

MOTOR STOPS WITHOUT WARNING

1. Broken ground wire, short-circuiting magneto.
2. Water on high tension terminals.
3. Magneto out of time (drive slipped).
4. Water or oil in safety spark gap.
5. Badly worn block (fiber) or breaker arm.

MOTOR RUNS IRREGULARLY OR MISFIRES

1. Loose wiring of terminals.
2. Broken spark plug insulator.
3. Spark plug points oiled or sooted.
4. Incorrect spark plug gap.
5. Leaking high tension lead.
6. Poor breaker point adjustment.
7. Wire broken inside of insulation.
8. Loose platinum point in breaker box.
9. Weak breaker arm spring.
10. Broken collector ring or collector brush.
11. Carbon dust or oil in distributor.
12. Worn fiber block or interrupter cam.
13. Oil-soaked magneto windings.
14. Weak magnets on magneto.
15. Oil on breaker points.

COMPRESSION TROUBLES

1. Broken valve.
2. Warped valve head.
3. Broken valve spring.
4. Bent or stuck valve stem.
5. Dirt or carbon under valve seat.
6. Leak between cylinder head and spark plug.
7. Leak between spark plug insulator and shell.
8. Leak at valve chamber cap.
9. Improper valve stem clearance.
10. Defective priming cock.
11. Broken piston rings.
12. Slots in piston rings in line.
13. Piston rings stuck in grooves.
14. Leaking cylinder head gasket.
15. Pitted valves.

CARBURETOR SYSTEM TROUBLES

MOTOR WILL NOT START, OR STARTS HARD

1. No gasoline in tank.
2. No gasoline in float chamber.
3. Tank shut-off closed.

4. Clogged filter screen.
5. Fuel supply pipe clogged or dented.
6. Gasoline level too low.
7. Gasoline level too high (flooding).
8. Bent or stuck float lever.
9. Loose or defective inlet manifold.
10. Cylinders flooded with gasoline.
11. Fuel-soaked float.
12. Leaking metal float.
13. Water in spray nozzle.
14. Dirt in float chamber.
15. Gasoline mixture.
16. Frozen carburetor (winter time).

MOTOR STOPS WITHOUT WARNING

1. Gasoline shut-off valve jarred closed.
2. Gasoline supply pipe clogged.
3. No gasoline in tank.
4. Spray nozzle stopped up.
5. Water in spray nozzle.
6. Broken air line or leaking tank (pressure).
7. Air vent in tank filler car closed, and float needle valve stuck.

MOTOR RUNS IRREGULARLY OR MISFIRES

Carburetor or float chamber getting dry, water or dirt in gasoline.

Too much gasoline, incorrect jet or choke, or broken cylinder head gasket between cylinders.

GAS ENGINE THEORY.

The eight figures on page 103 are intended to make clear the operation of a gasoline engine. Figures 1, 2, 3, and 4 represent the cylinder of a gasoline engine, and figures 5, 6, 7, and 8 represent the barrel of a cannon. At "A" in Figure 1 is the intake, "B" the spark plug, and "C" the exhaust. At "E" in Figure 5 is point where fuse is placed. "F" is the ball, "G" is the powder (fuel), and "H" is the barrel of the cannon. At "I" in Figure 6 is shown the Tamper used to compress the fuel in the cannon, and at "J" in Figure 8 is shown the "swab" used to clean the barrel of the cannon.

In Figure 1 fuel is being drawn into the cylinder, and in Figure 5 fuel is being placed in the cannon. In Figures 2 and 6 the fuel is being compressed into a small space. In Figures 3 and 7 the fuel has been ignited. In Figure 3 the piston is forced downward, and in Figure 7 the ball is forced from the cannon. In both cases the movement was due to rapid expansion due to ignition of the fuel. In Figures 4 and 8 the burned gasses are being forced out of the chamber. In Figure 4 we say the piston forces the burned gasses out through the exhaust, while in Figure 8 the barrel of the cannon is being cleaned out. The operation of a gasoline engine is very similar to that of the cannon, as just described.

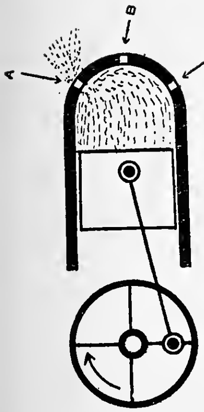


FIG. 1

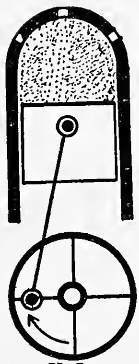


FIG. 2

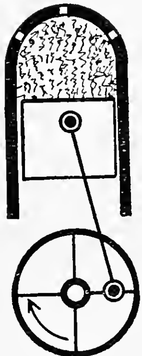


FIG. 3

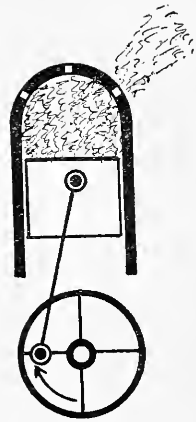


FIG. 4

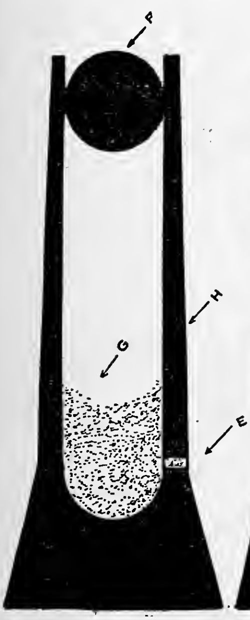


FIG. 5

FIG. 6

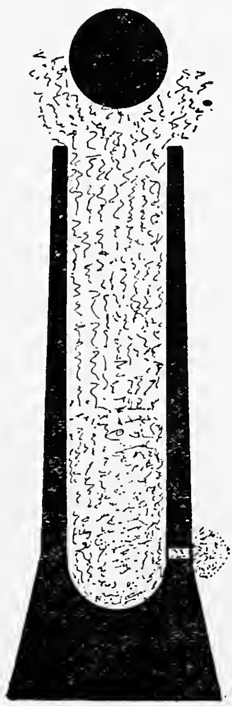


FIG. 7

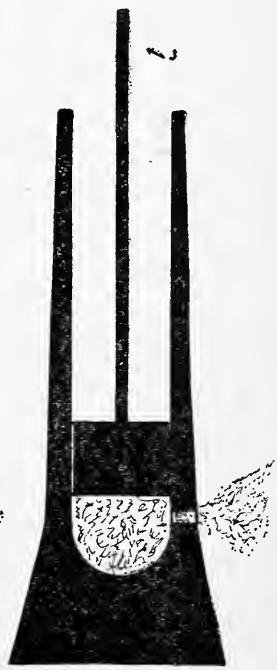


FIG. 8

SECTION 4

DELCO SYSTEMS

1910 TO 1915 INCLUSIVE

INSTRUCTION, OPERATION, AND CARE

WIRING DIAGRAMS

Internal Circuits of Ignition Relay, Cut-Out Relay, Circuit-Breaking Relay, Vibrating-Regulator Relay, Coils, Voltage Regulator, Switches, Motor Generators, and All Important Parts and Wiring Diagrams of DELCO SYSTEMS

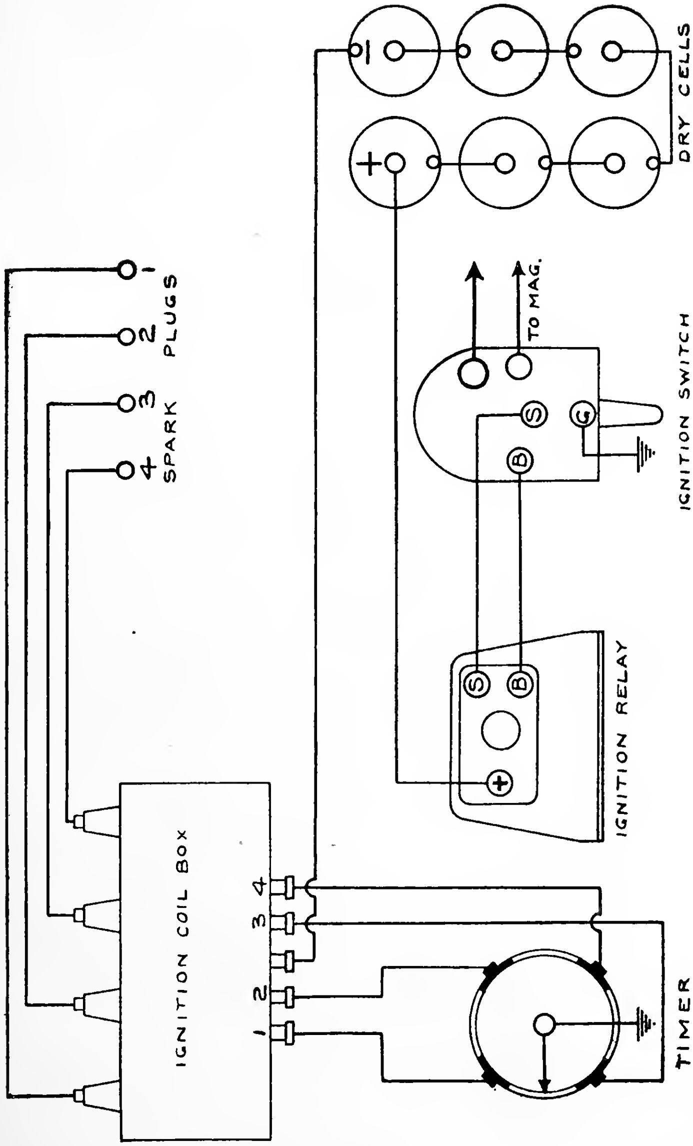


Fig. 1.
1910 CADILLAC

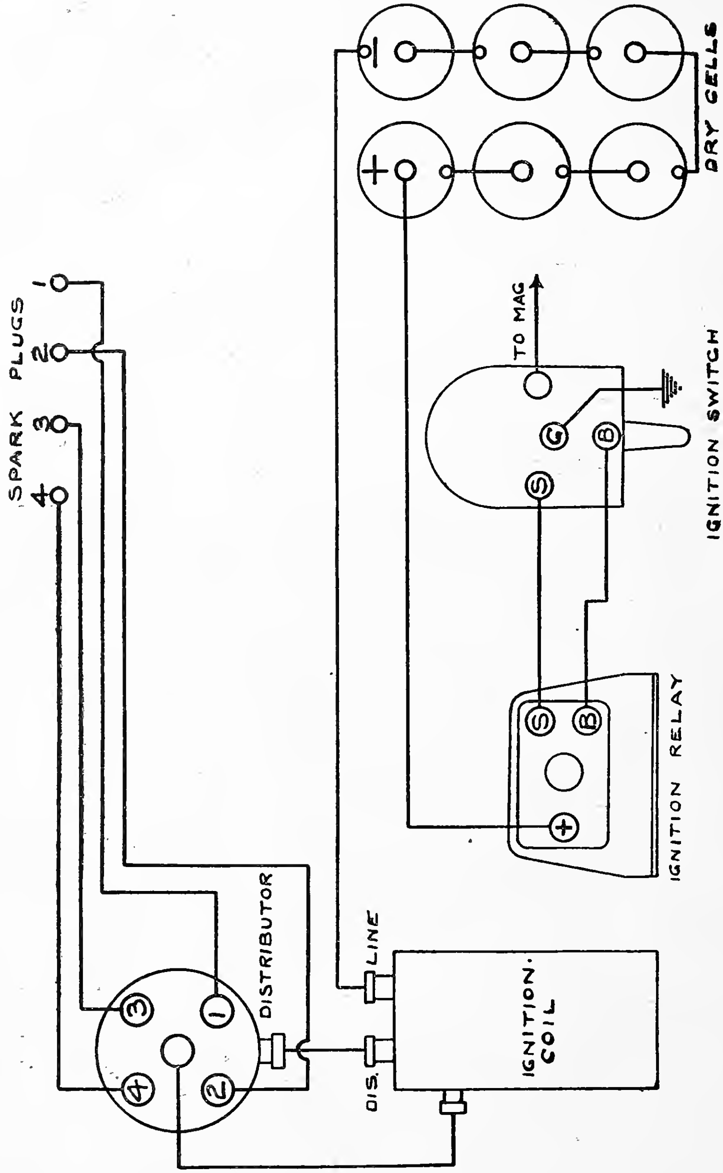


Fig. 2.
1911 CADILLAC

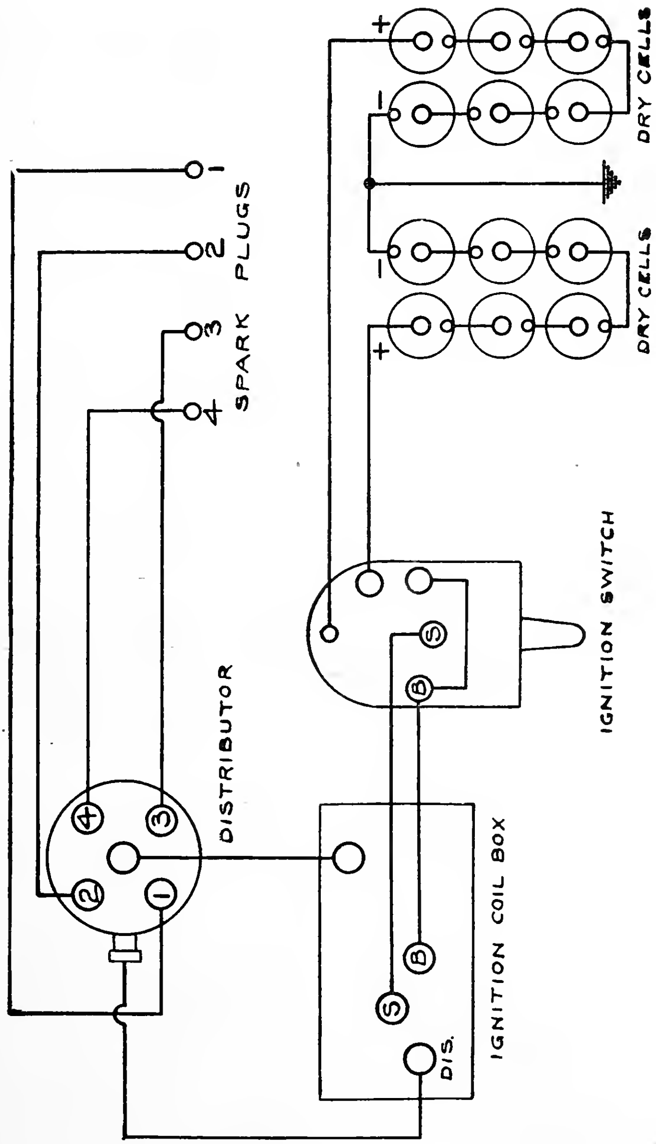


Fig. 3.
1912 PAIGE DETROIT

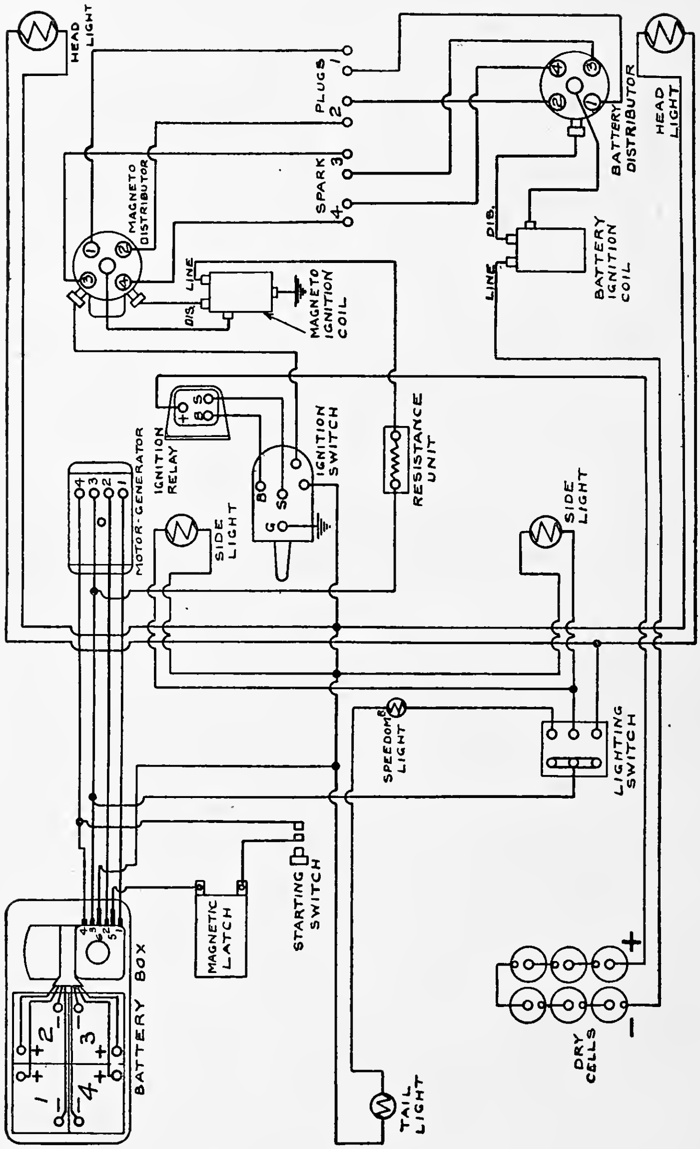


Fig. 4.
1912 CADILLAC

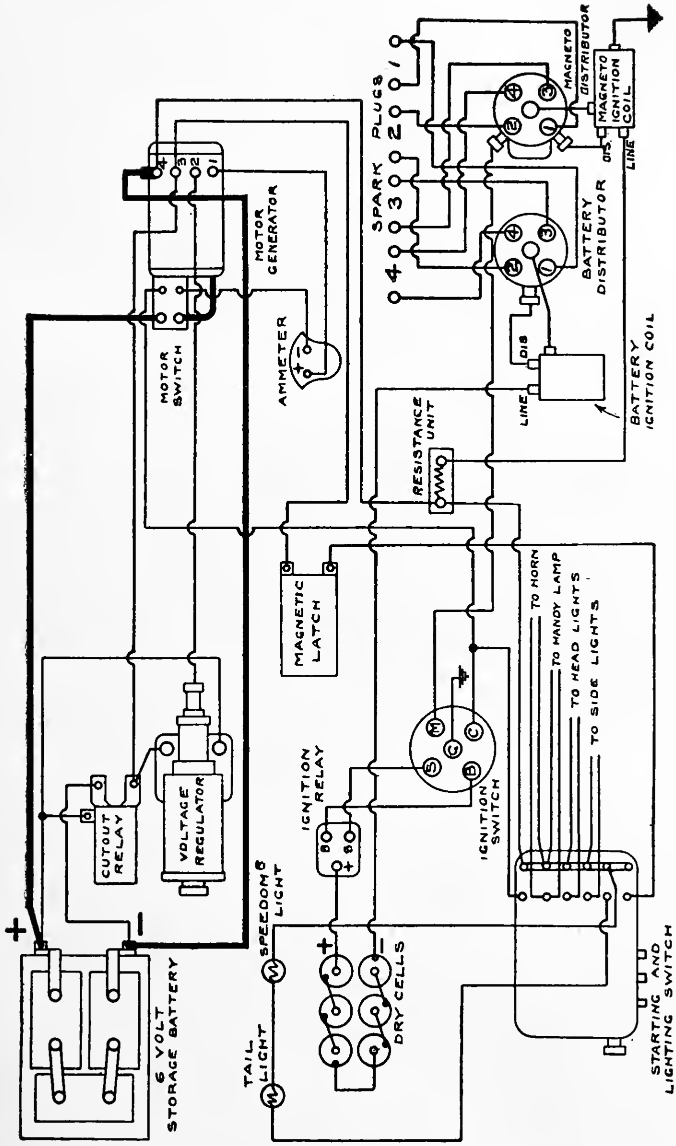


Fig. 5.
1913 CADILLAC

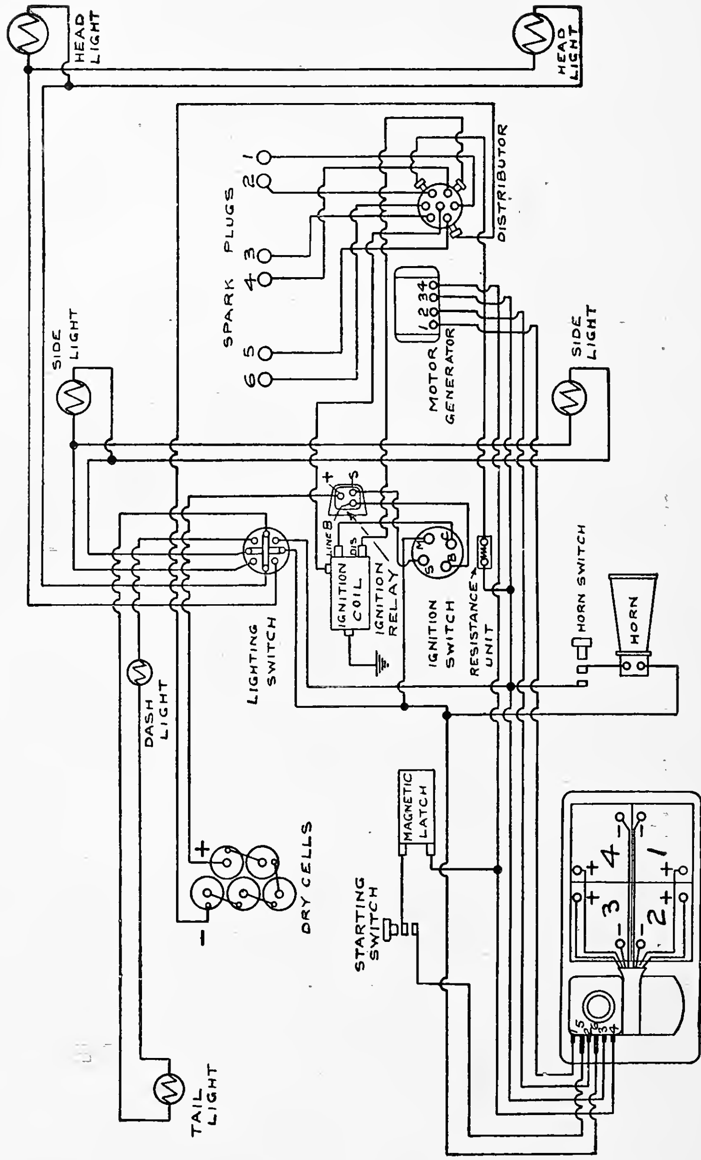


Fig. 6.

1913 COLE 4-40, 4-50 and 4-60. 1913 OAKLAND 4-42 and 6-60

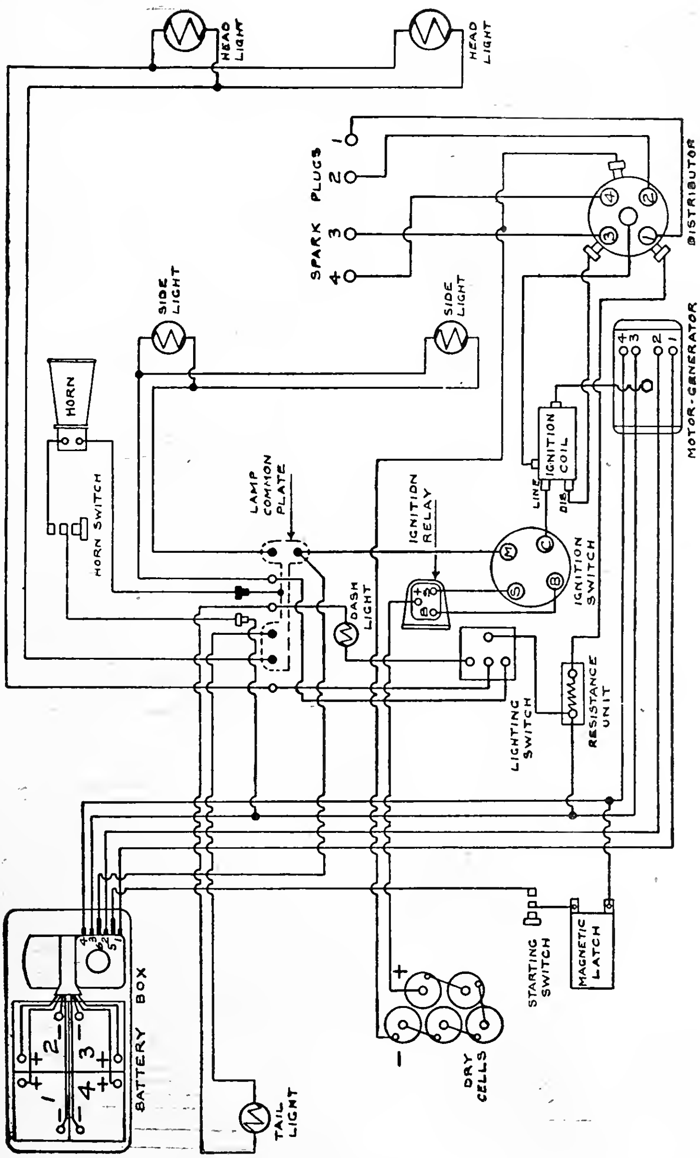


Fig. 7.
1913 HUDSON 37 and 6-54

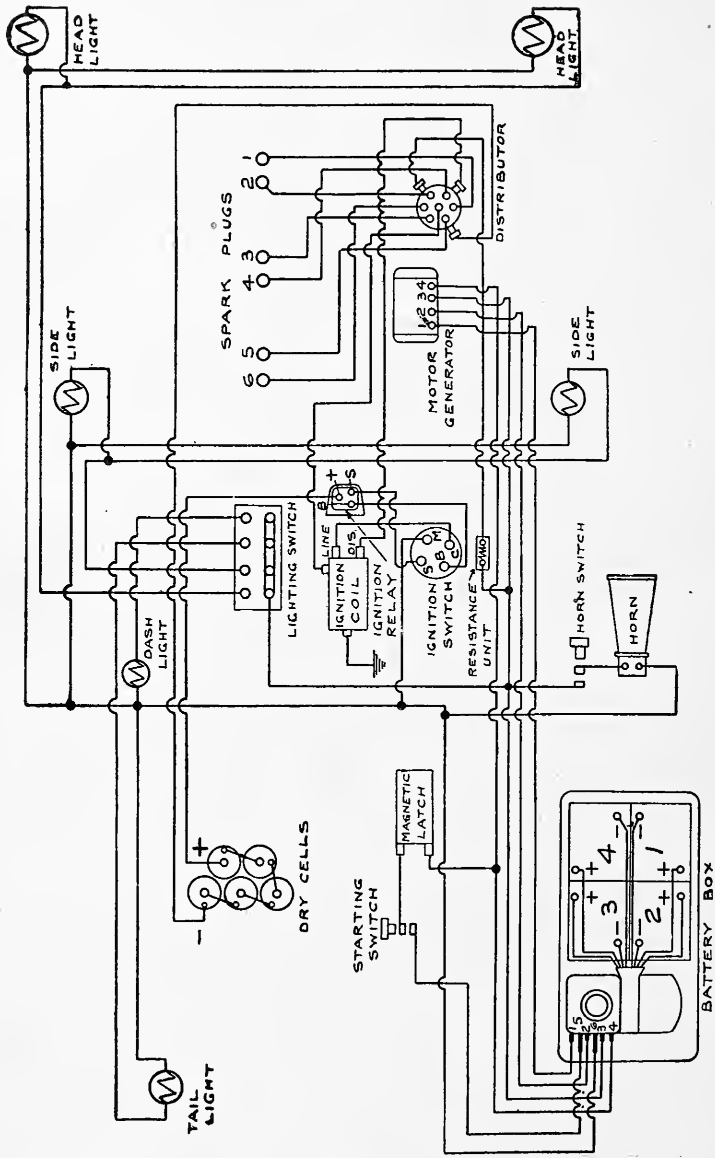


Fig. 8.
1913 OLDSMOBILE

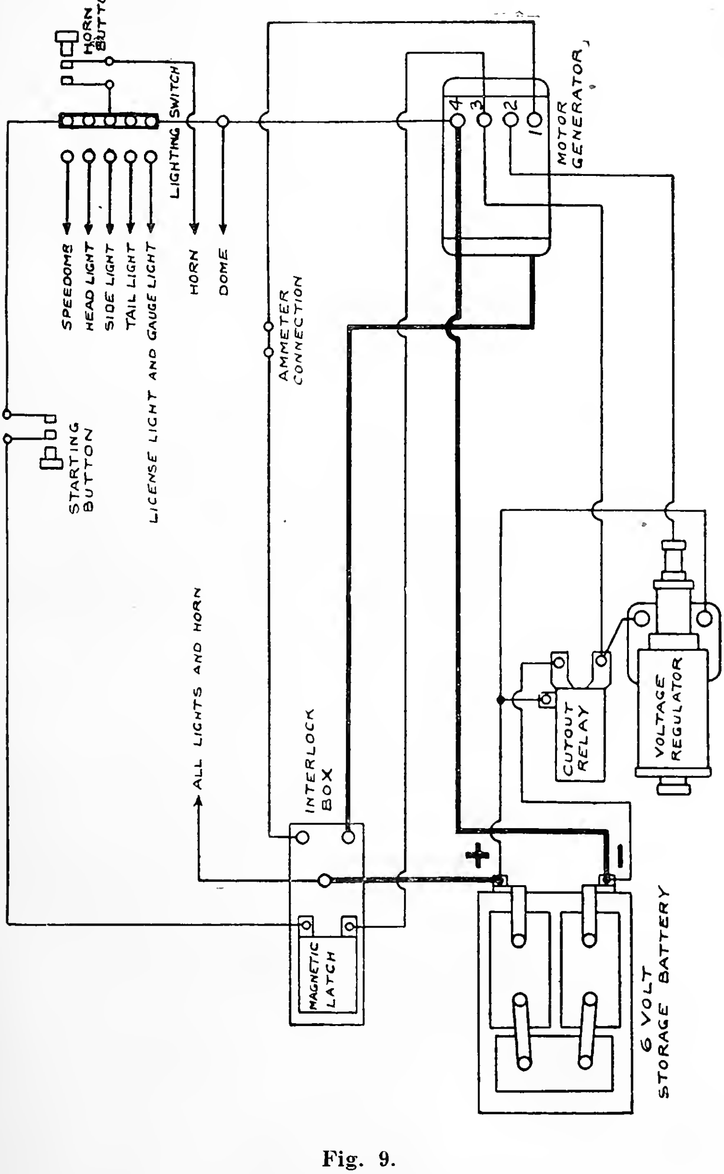


Fig. 9.
PACKARD 13-38

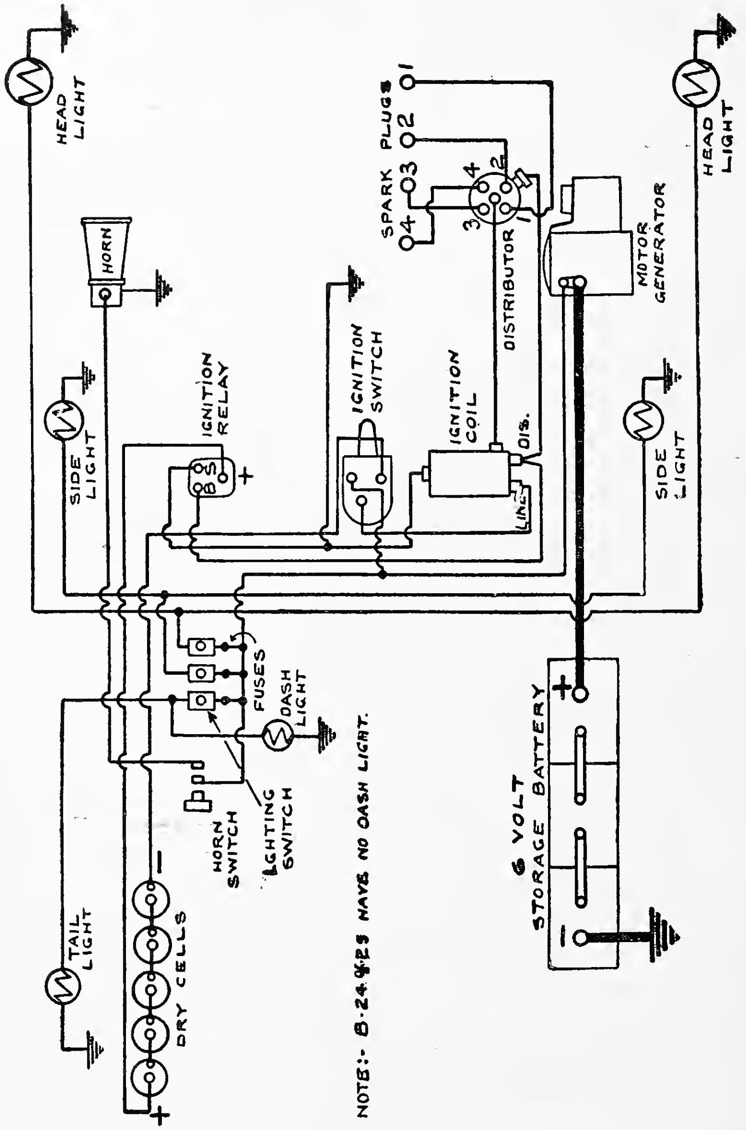


Fig. 10.
1914 BUICK B-24, 25 and B-36, 37

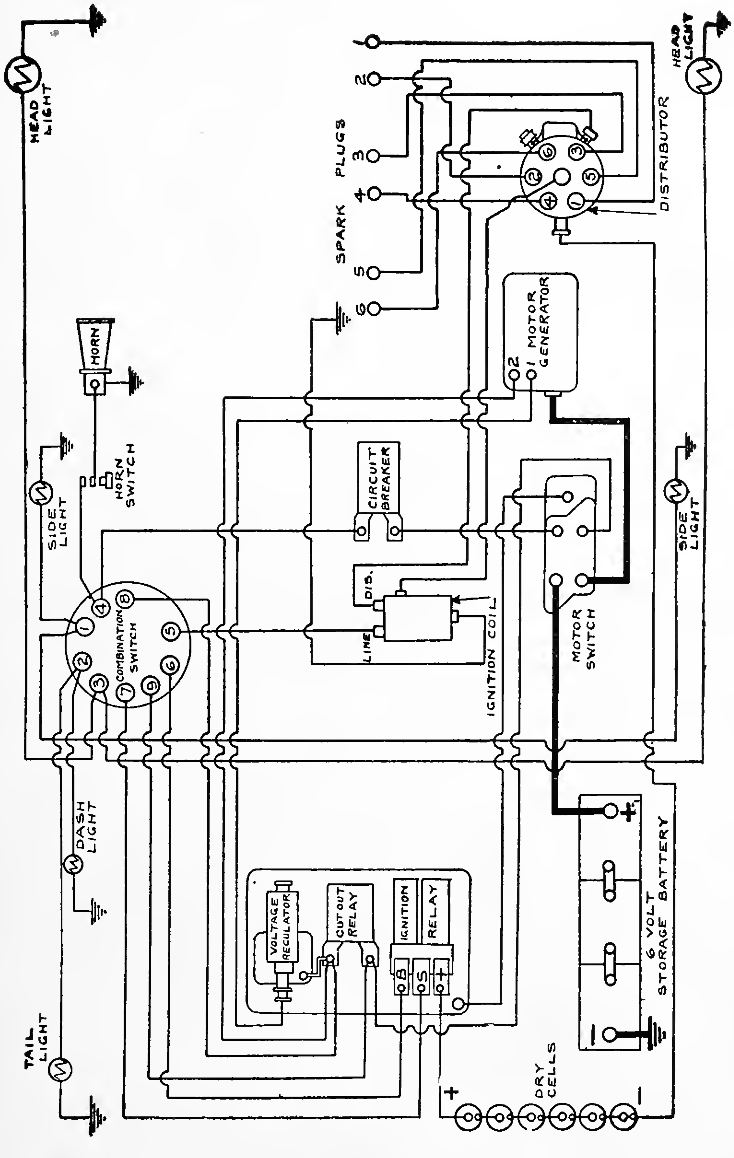


Fig. 11.
1914 BUICK B-54, 55

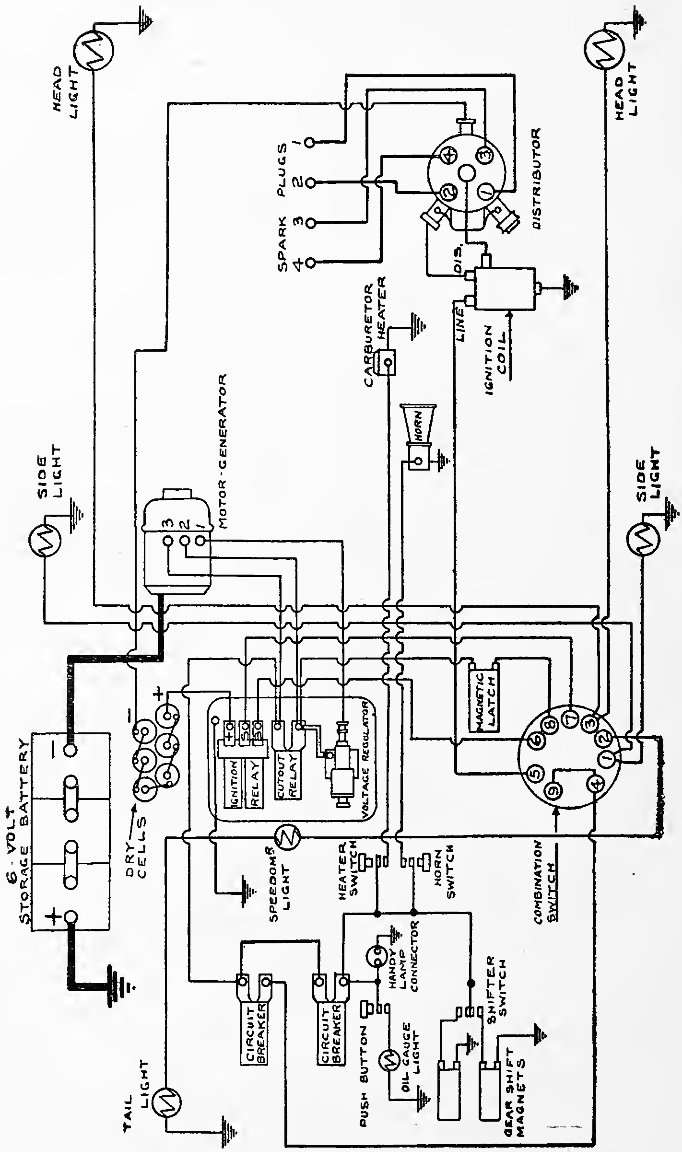


Fig. 12.
1914 CADILLAC

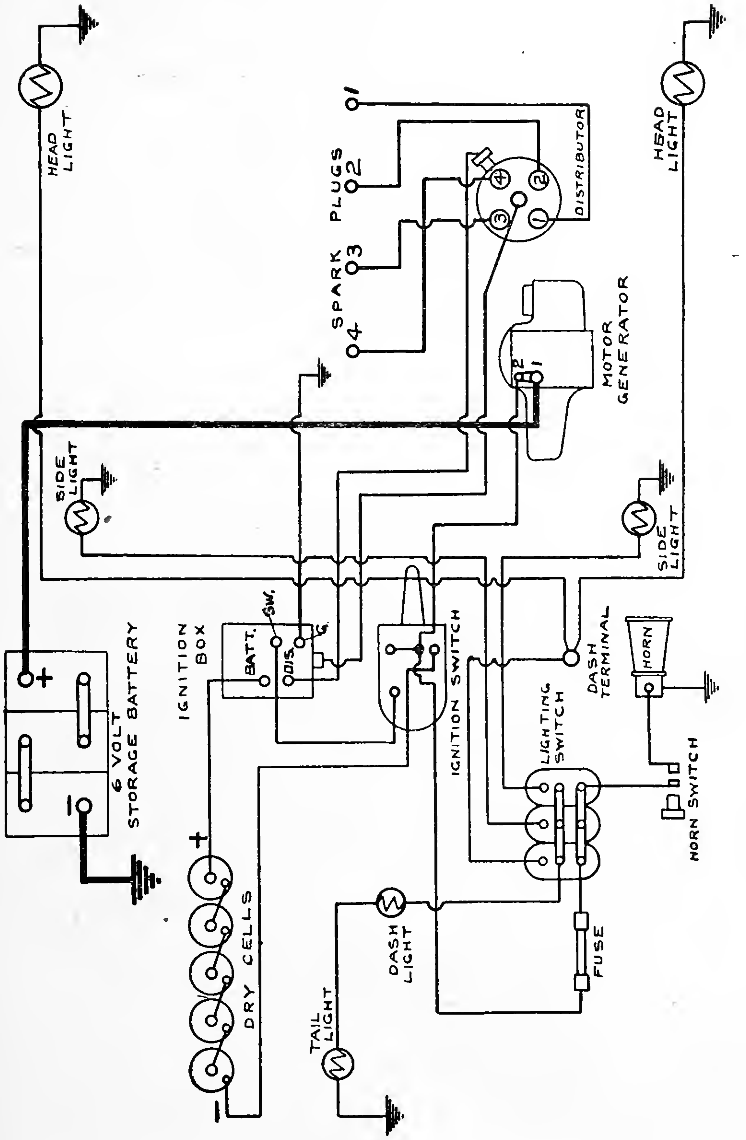


Fig. 13.
1914 CARTERCAR 7

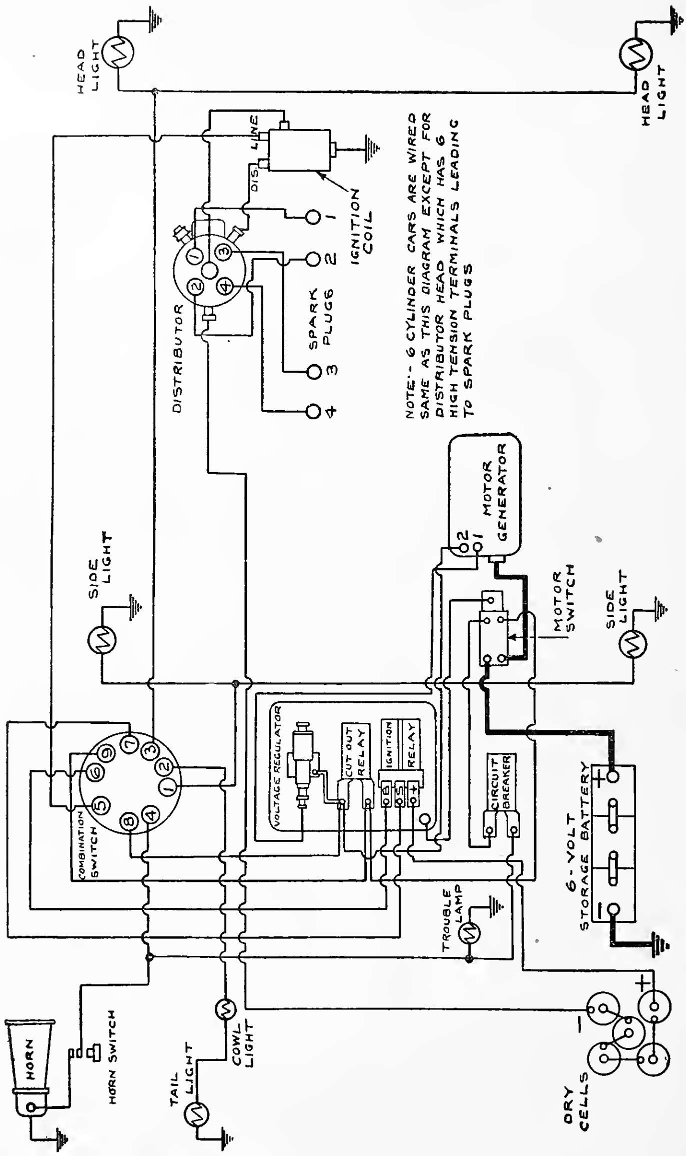


Fig. 14.

1914 COLE 4-40, 4-50 and 6-60. 1914 MOON 4-42 and 6-50

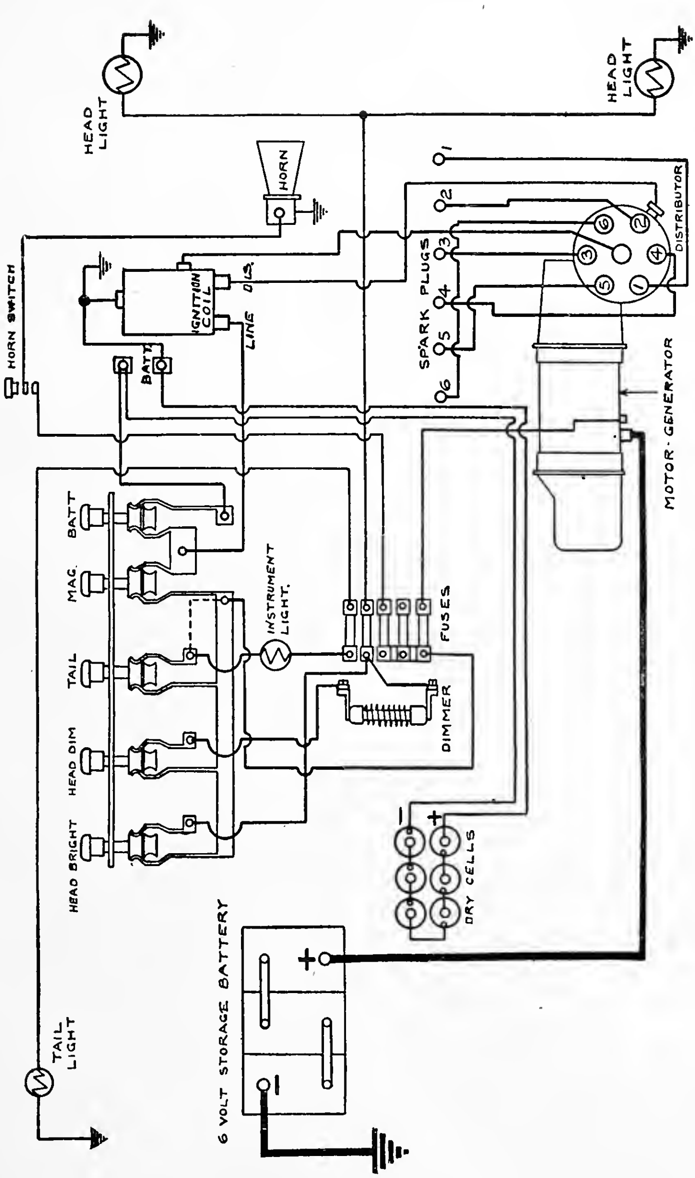


Fig. 15.
1914 HUDSON 6-40

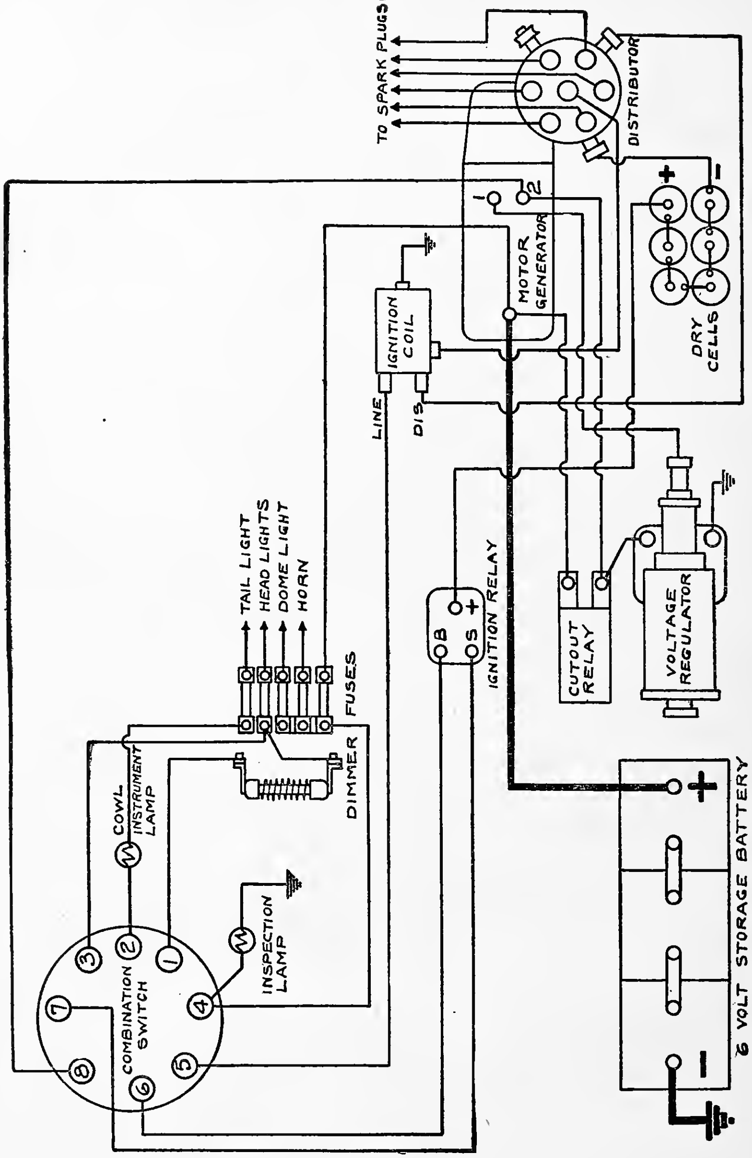


Fig. 16.
1914 HUDSON 6-54

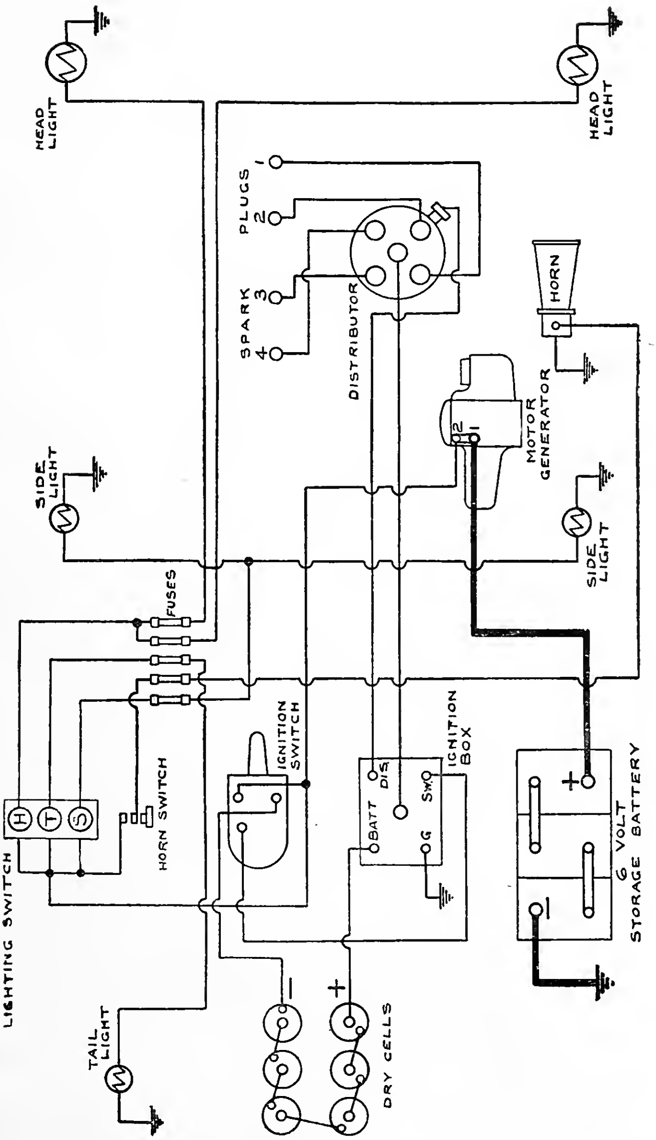


Fig. 17.

1914 OAKLAND 36. 1914 PATERSON 32 and 33

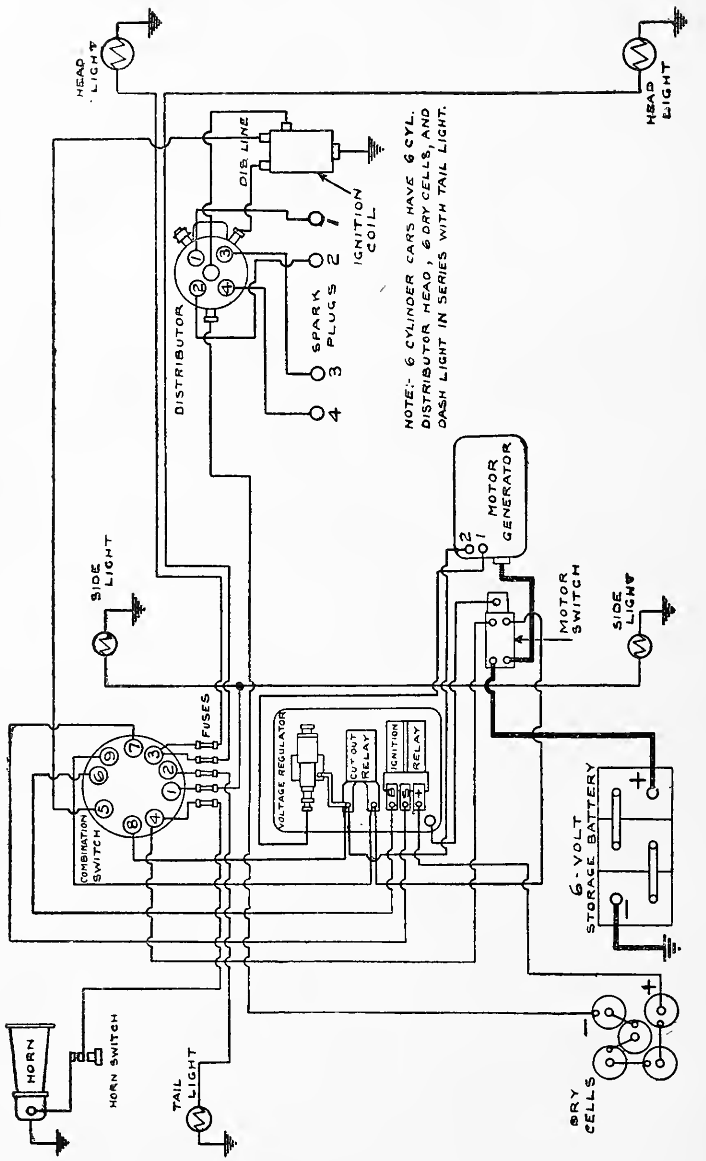


Fig. 18.
1914 OAKLAND 43, 48 and 62

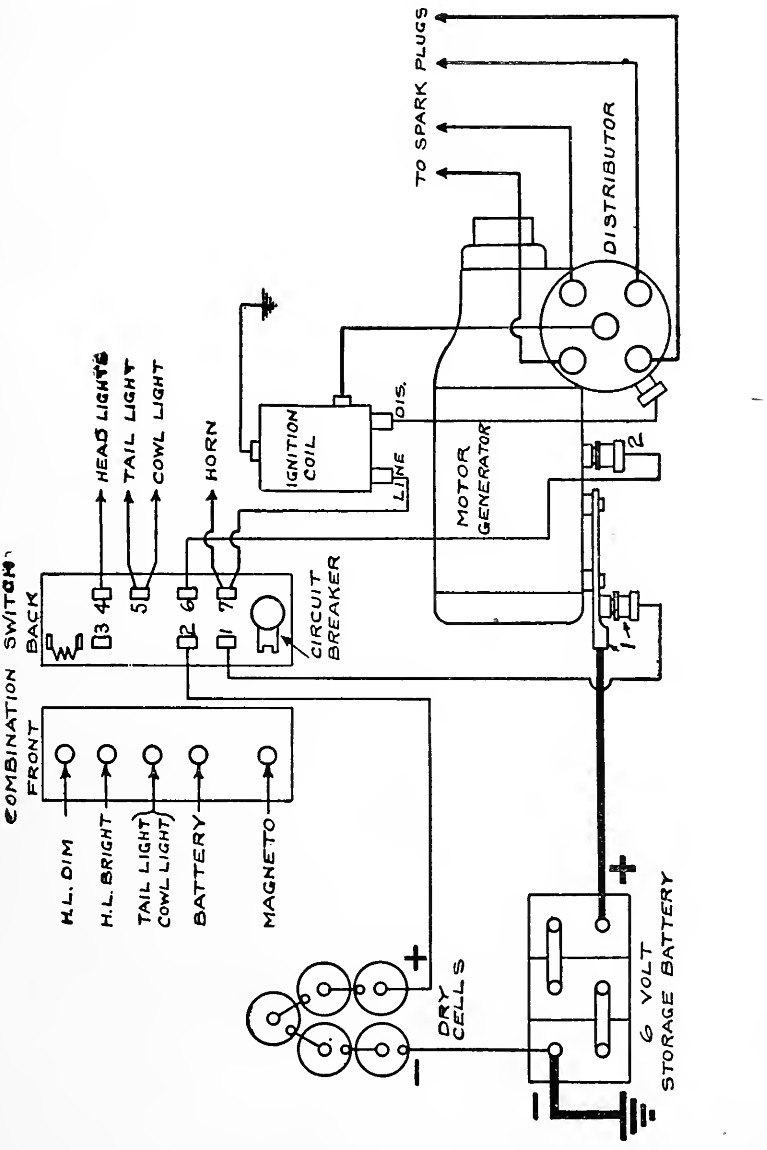


Fig. 19.
1914 OLDSMOBILE 42

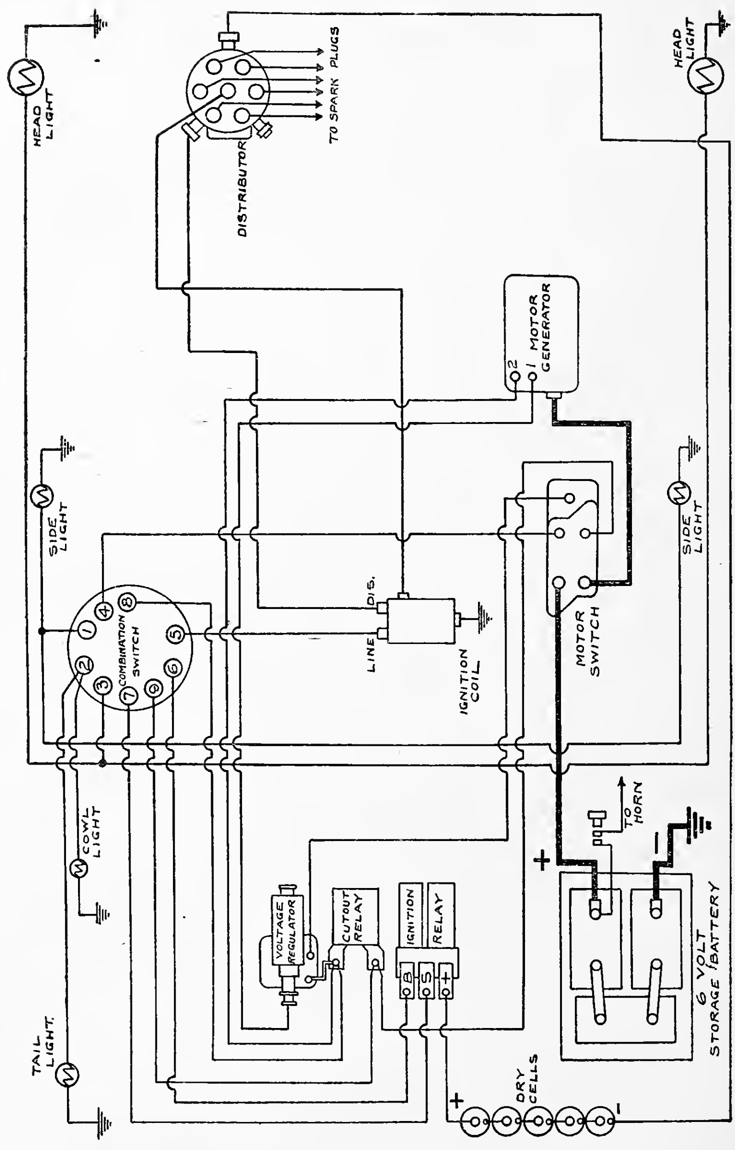


Fig. 20.
1914 OLDSMOBILE 6

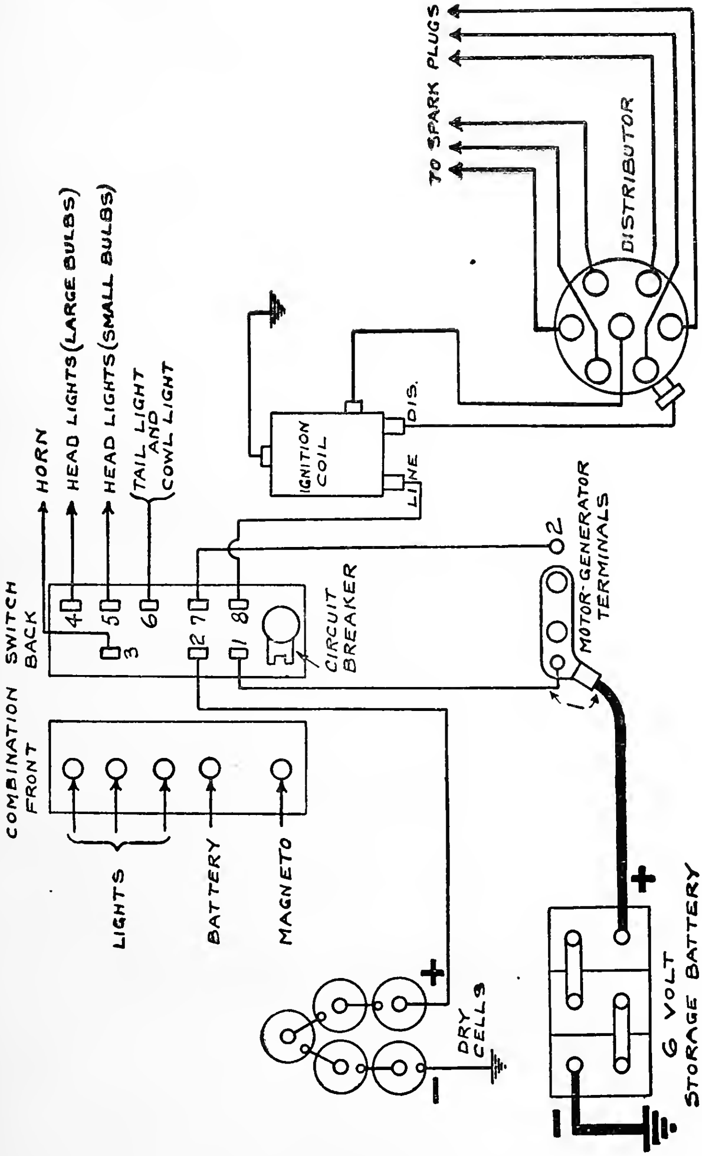


Fig. 21.
1915 AUBURN 6-40. 1915 JACKSON 48.

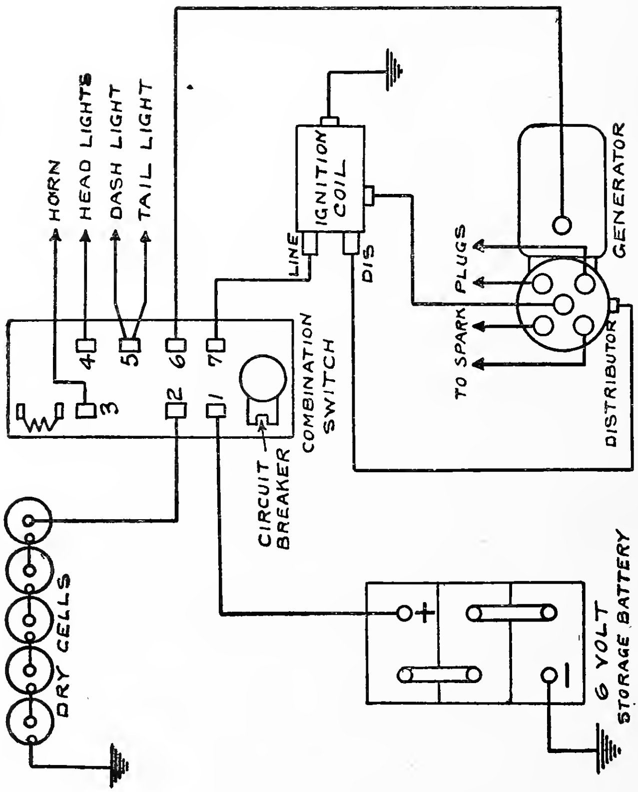


Fig. 22.
1915 BUICK TRUCK

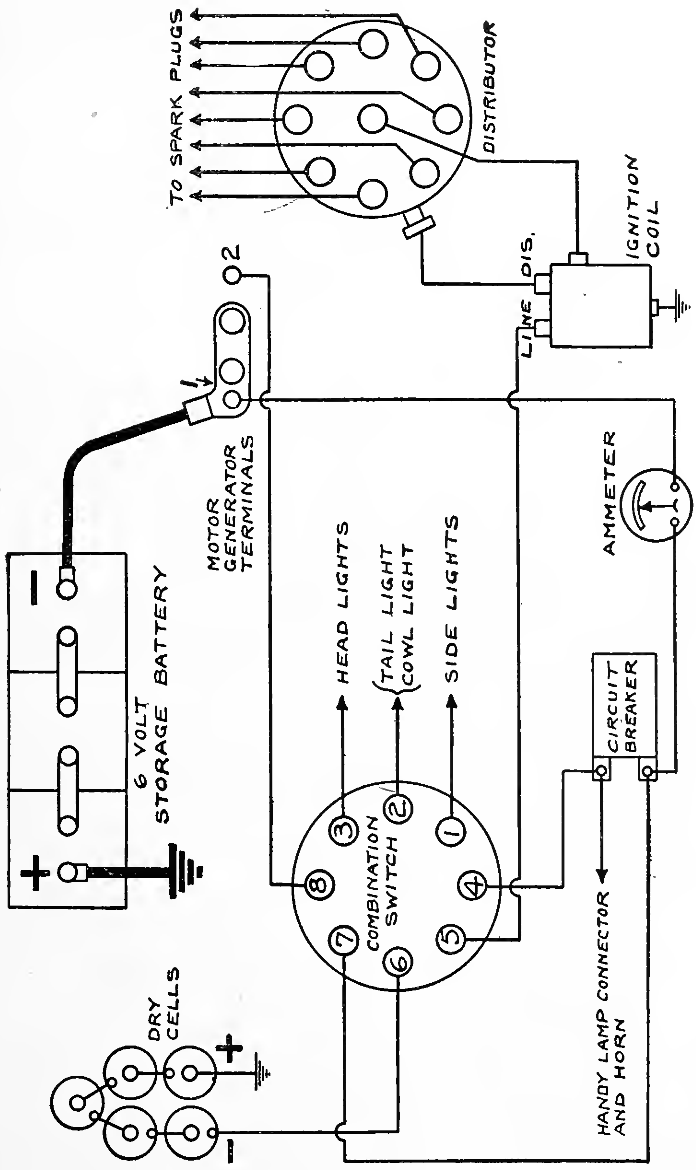


Fig. 23.
1915 CADILLAC 8

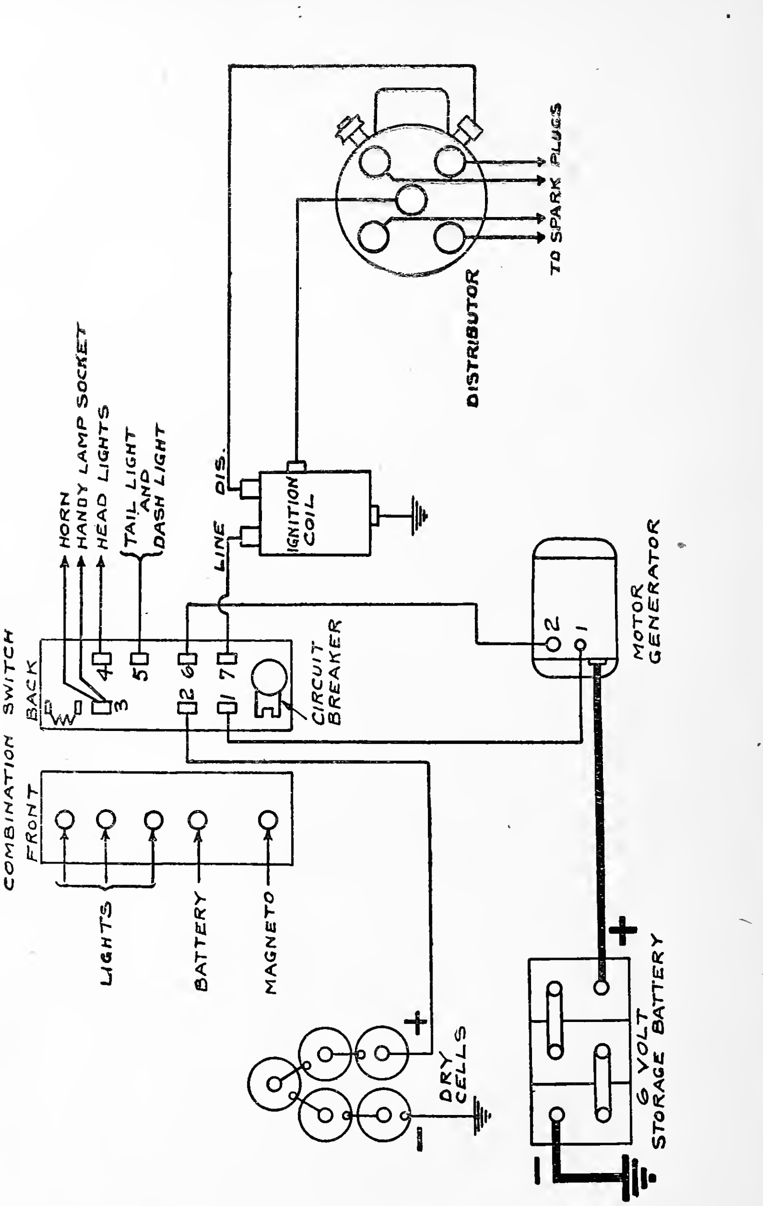


Figure 24
1915 COLE 4-40

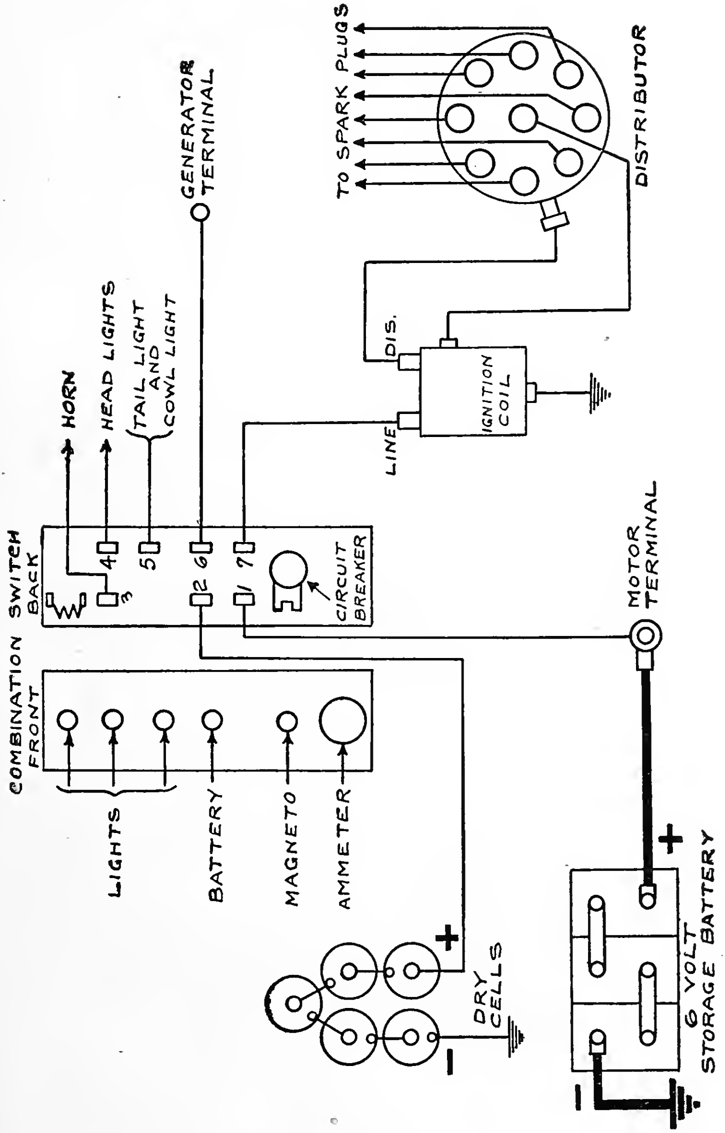


Fig. 25.
1915 COLE 8

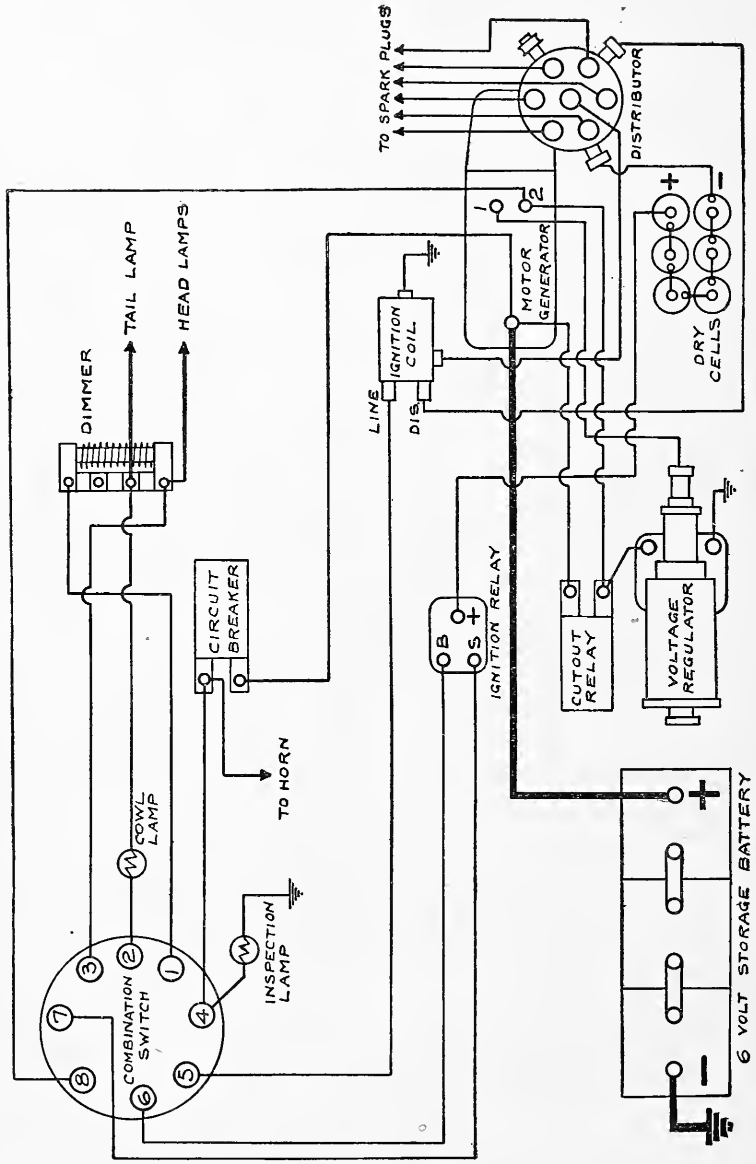


Fig. 26.
1915 HUDSON 6-54

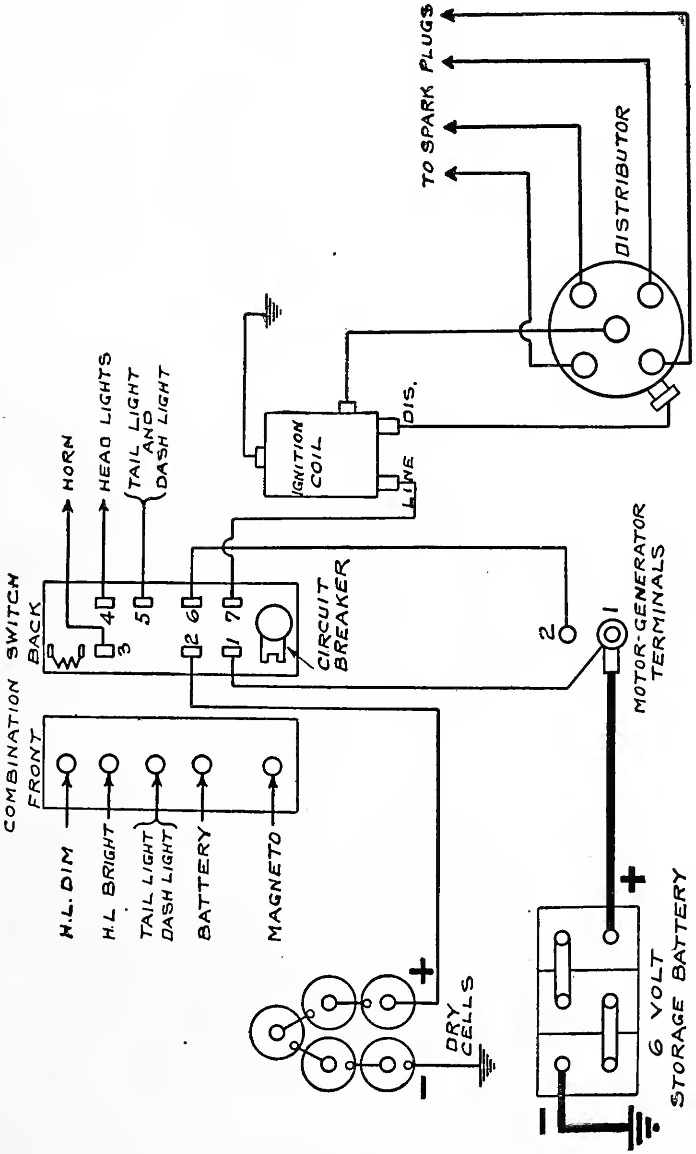


Fig. 27.

1915 BUICK C 24, 25. 1915 CARTERCAR 9

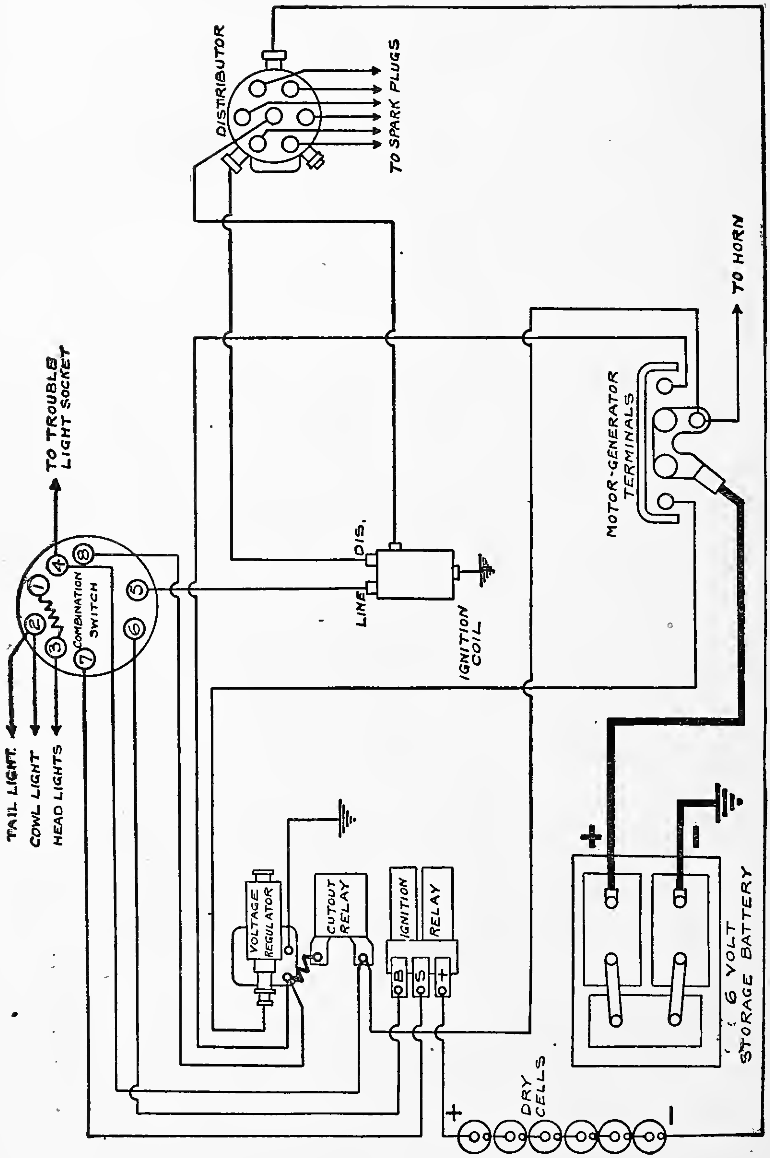


Fig. 28.
1915 OLDSMOBILE 6-55

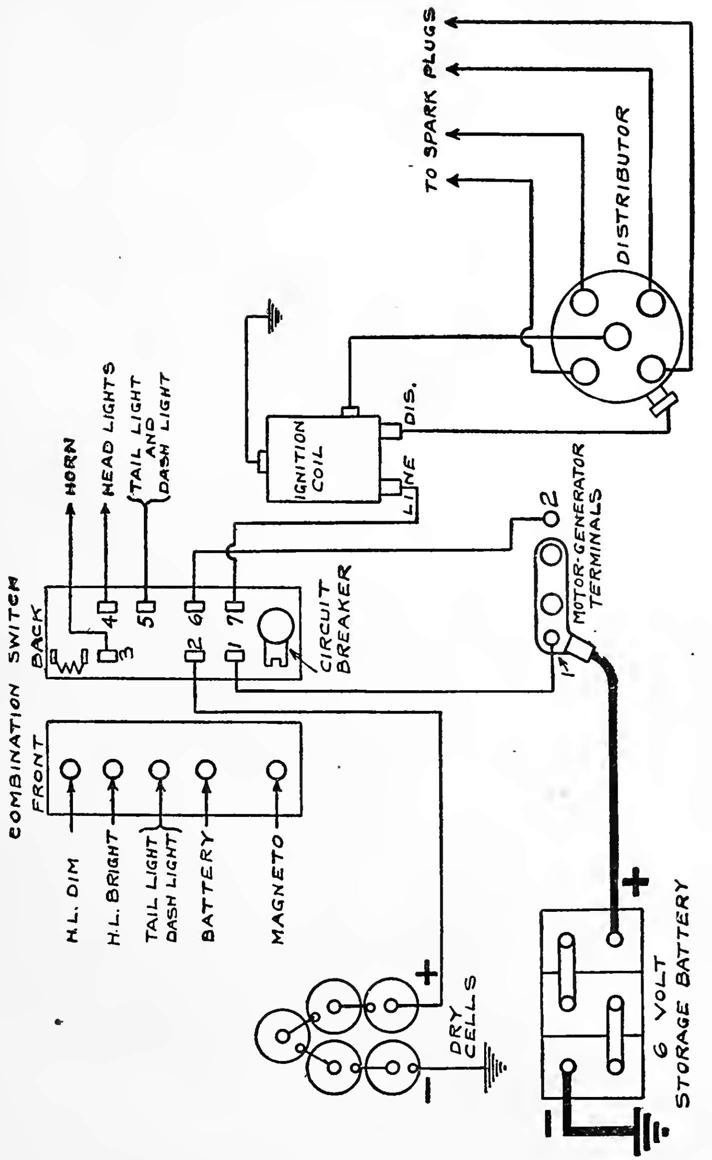


Fig. 29.

1915 BUICK C 36, 27. 1915 BUICK C 54, 55

1915 COLE 6-50
1915 HUDSON 6-40
1915 MOON 6-40
1915 MOON 6-60
1915 PATERSON
1915 OAKLAND 37 and 49
1915 OLDSMOBILE 42
1915 WESTCOTT-U

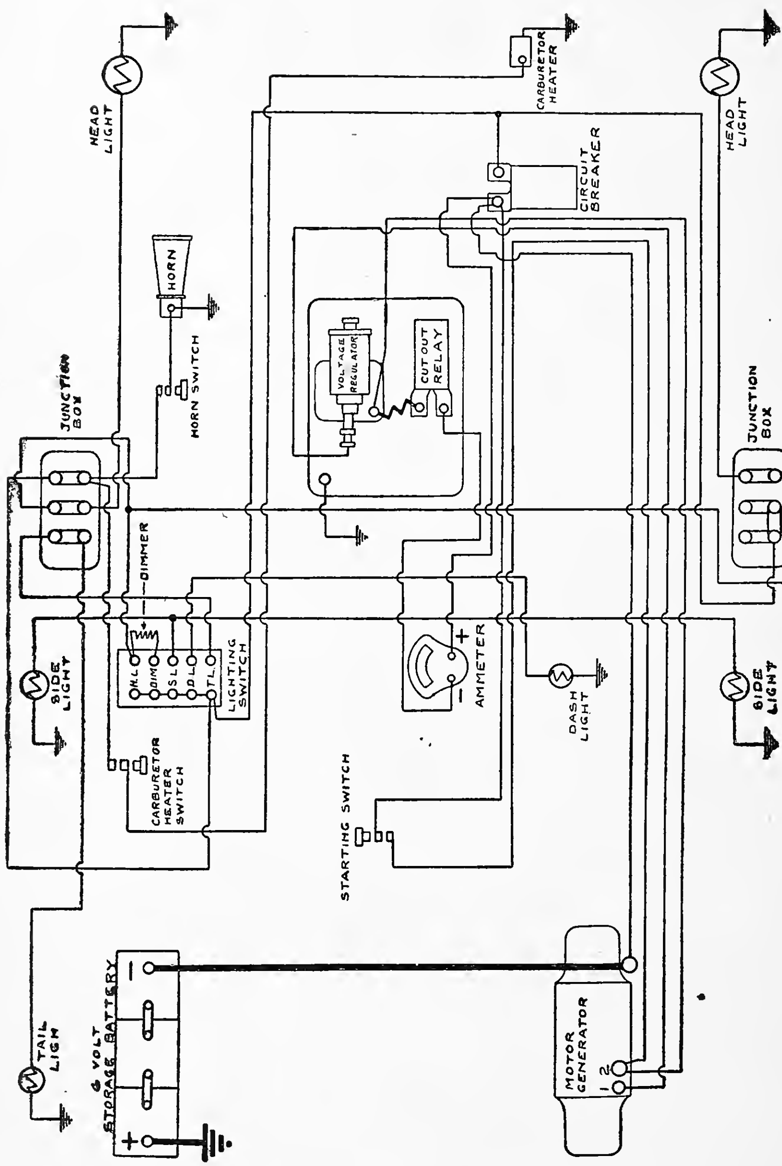


Fig. 30.
1915 STEVENS-DURYEA

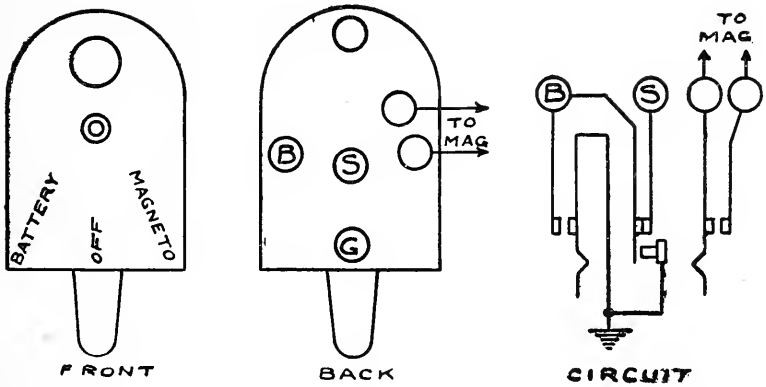


Fig. 31.
1910 and 1912 CADILLAC

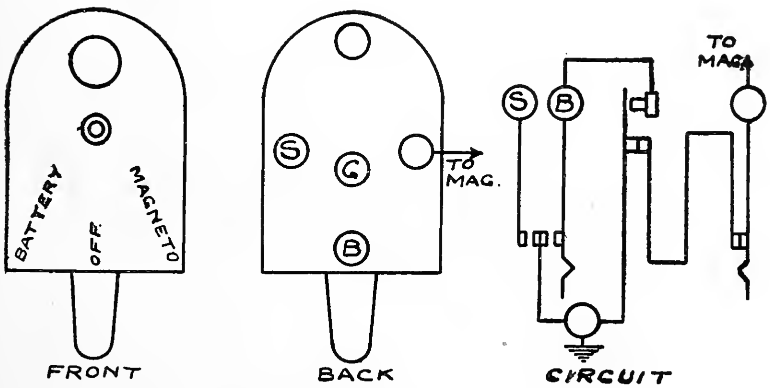


Fig. 32.
1911 CADILLAC

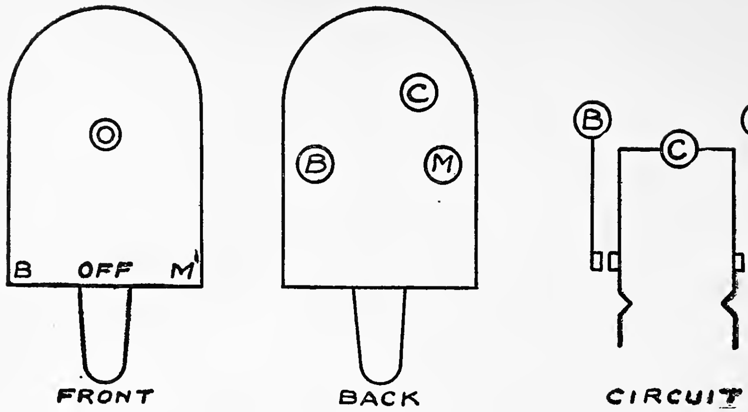


Fig. 33.
1914 BUICK B 24, 25 and 36, 37
1914 CARTERCAR 7 1914 OAKLAND 36 1914 PATERSON

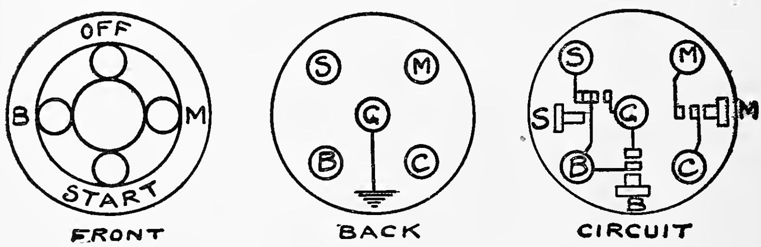


Fig. 34.
1913 CADILLAC

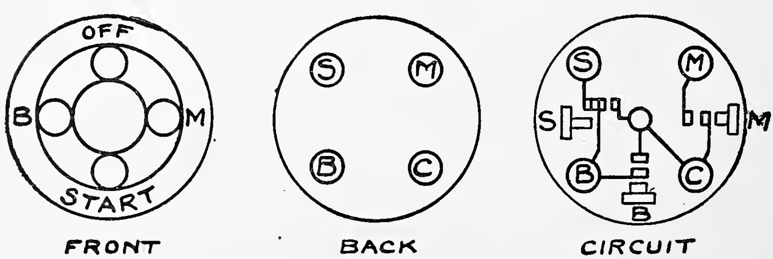


Fig. 35.
ALL 1913 COLE, HUDSON, OAKLAND and OLDSMOBILE

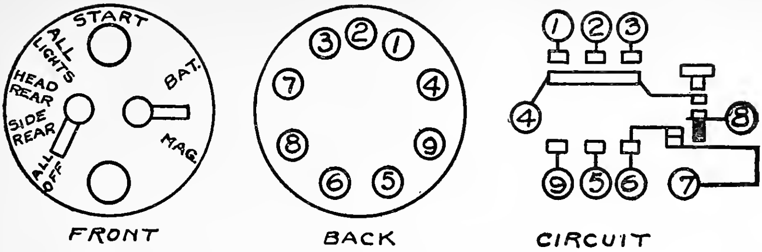


Fig. 36. 1914 CADILLAC

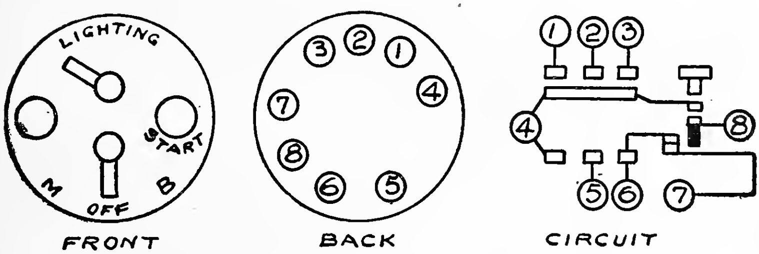


Fig. 37. 1914 HUDSON

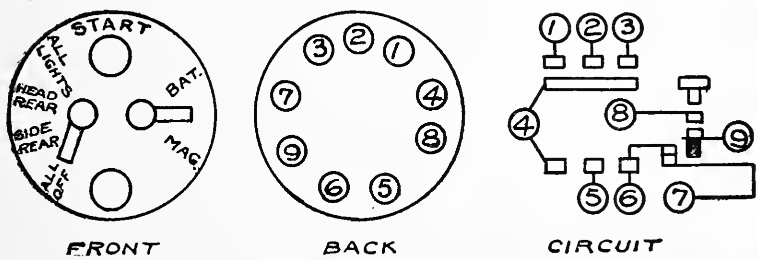


Fig. 38. 1914 BUICK B 54, 55

1914 OAKLAND 43, 48 and 62

1914 MOON 4-12 and 6-50

1914 OLDSMOBILE 6-54

1914 COLE 4-40, 4-50 and 6-60

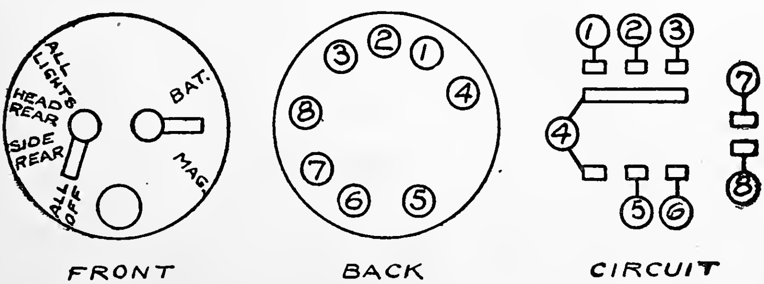


Fig. 39. 1915 CADILLAC 8

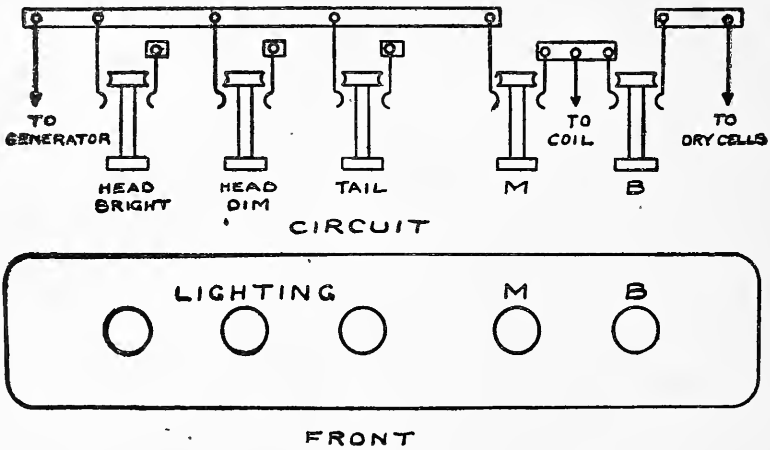


Fig. 40.
1914 HUDSON 6-40

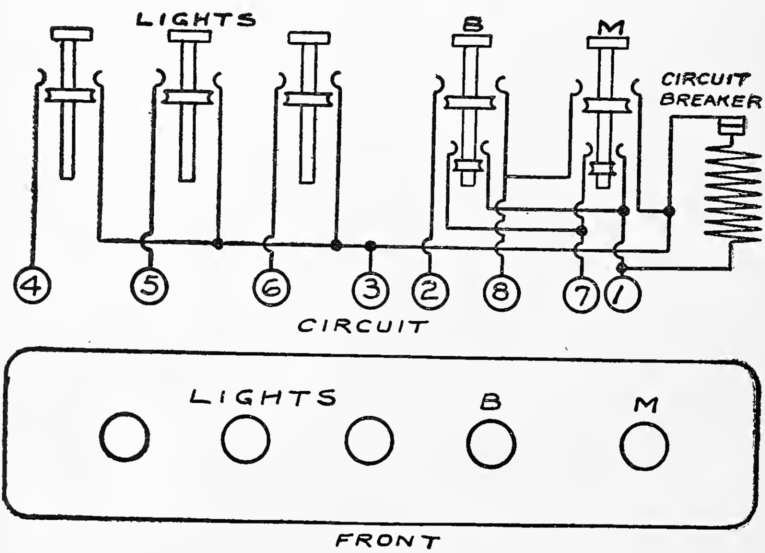


Fig. 41.
1915 JACKSON

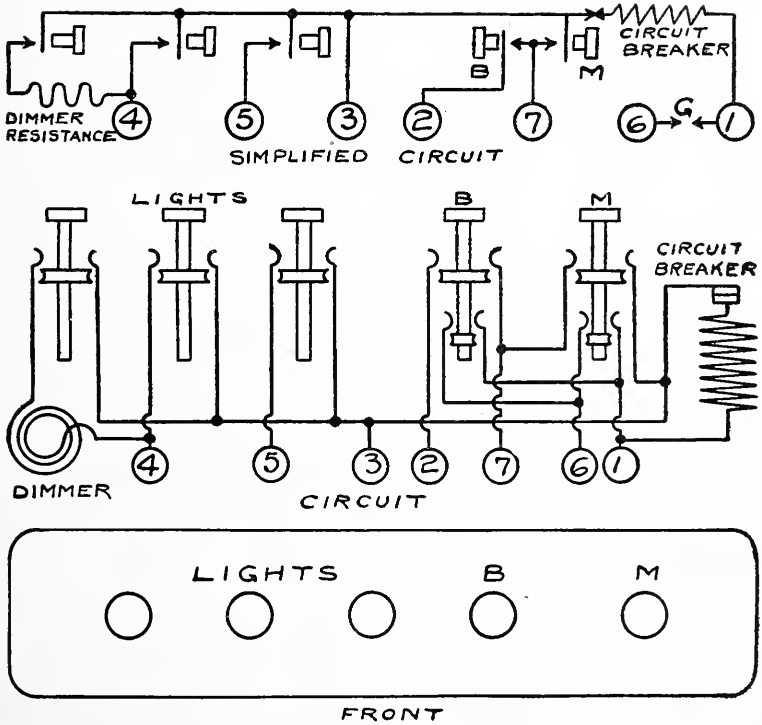


Fig. 42.

1915 BUICK TRUCK
1915 BUICK C 24, 25
1915 BUICK C 36, 37
1915 BUICK C 54, 55
1915 CARTERCAR
1915 COLE 4-40
1915 COLE 6-50
1915 HUDSON 6-40
1915 MOON 6-40
1915 OAKLAND 37 and 49
1915 OLDSMOBILE 42
1915 MOON 6-60
1915 PATERSON
1915 WESTCOTT-U

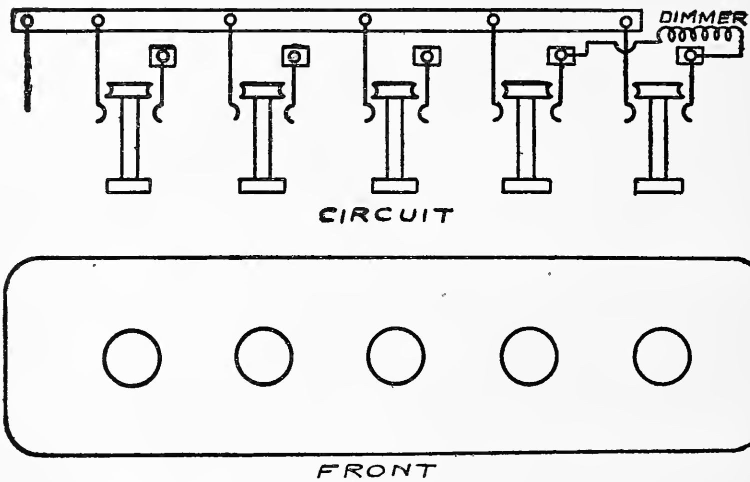


Fig. 43.
1915 STEVENS-DURYEA

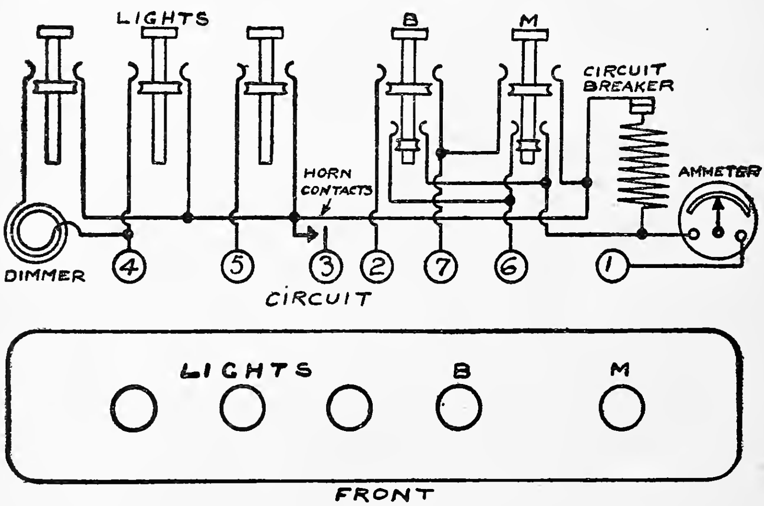


Fig. 44.
1915 COLE 8

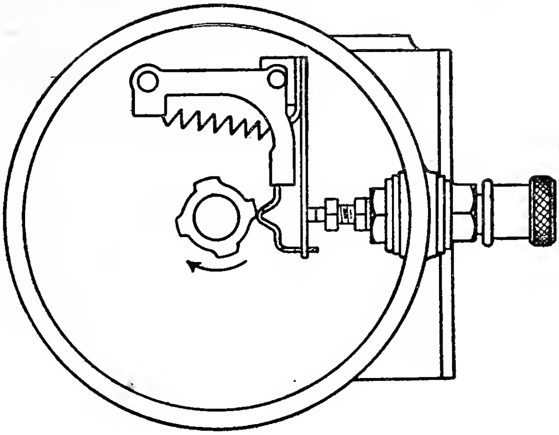


Fig. 45.
1911, 1912 and 1913 BATTERY SYSTEMS

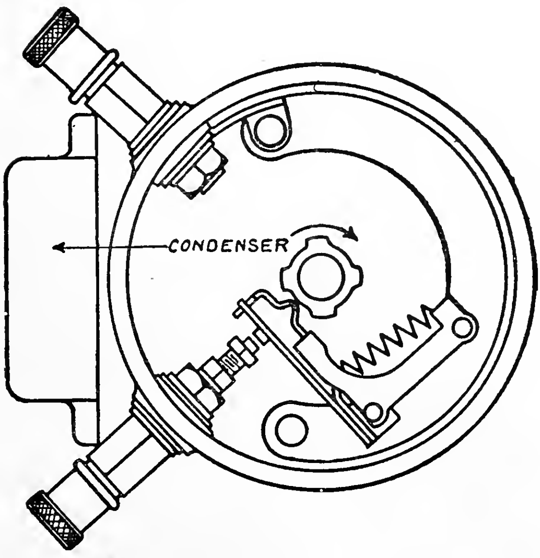


Fig. 46.
1912 and 1913 MAGNETO SYSTEMS

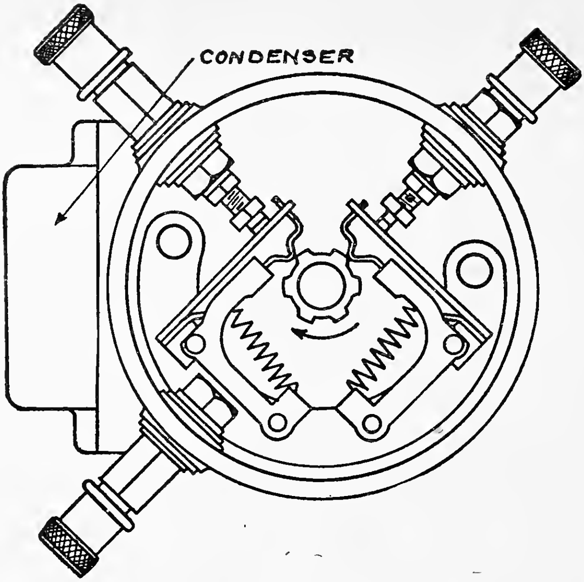


Fig. 47.
1913 OLDSMOBILE 6-53

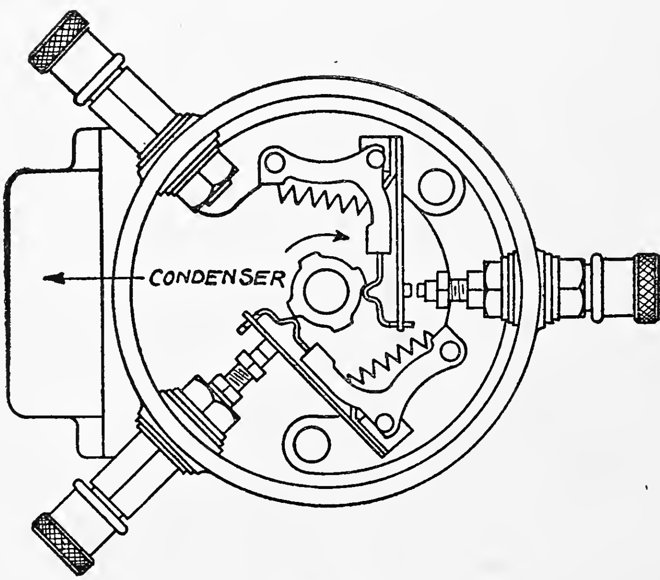


Fig. 48.
1913 COLE 4-40, 4-50 and 4-60
1913 HUDSON 37 and 6-54 1913 OAKLAND 4-42 and 6-60

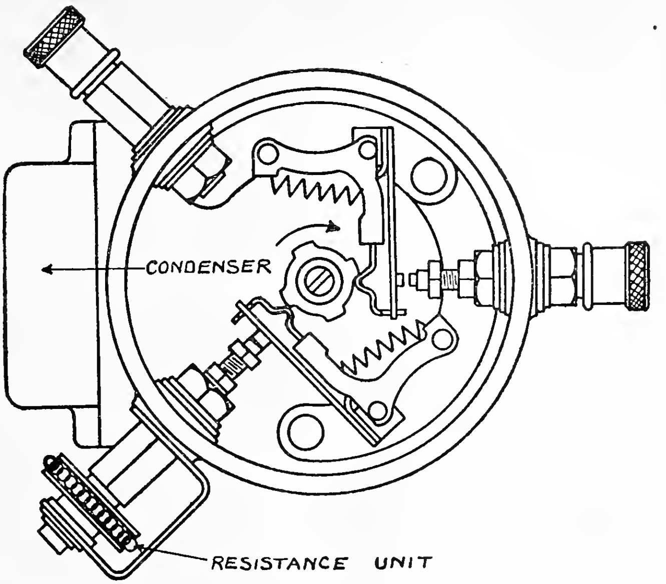


Fig. 49.

1914 BUICK B-54, 55
1914 CADILLAC
1914 COLE, 4 and 6 Cyl.
1914 HUDSON 6-54
1915 HUDSON 6-54
1914 OAKLAND 48 and 6-60
1914 MOON
1914 OLDSMOBILE 6-54
1915 OLDSMOBILE 6-55

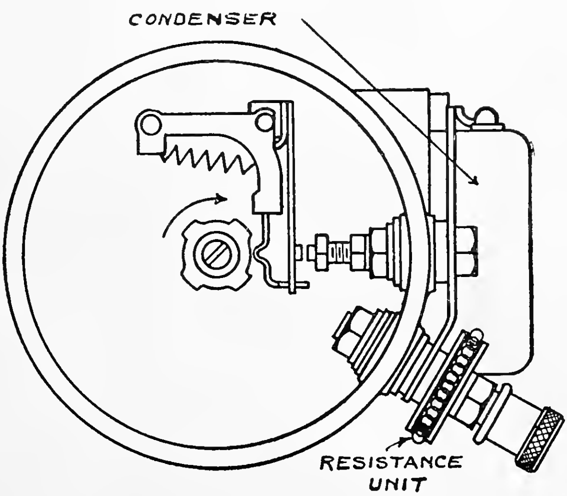


Fig. 50.

1914 BUICK B 24, 25, 36 and 37
1915 BUICK C 24, 25
1914 CARTERCAR 7
1915 CARTERCAR 9
1914 HUDSON 6-40
1914 OAKLAND 36
1914 PATERSON

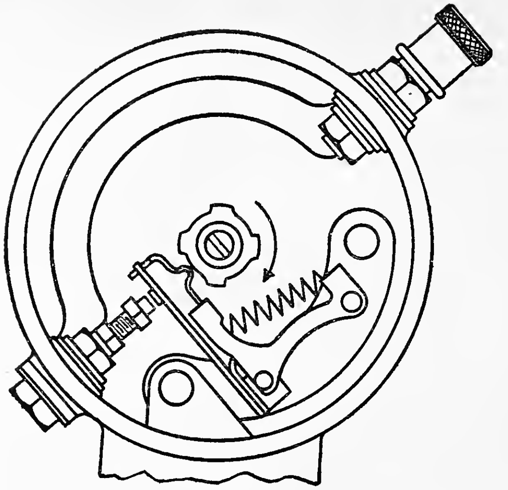


Fig. 51.

1915 BUICK C 36, 37 and 54, 55
1915 HUDSON 6-40

1915 OAKLAND 37 and 49
1915 Auburn
1915 COLE 6-50
1915 MOON 6-40 and 6-60

1915 OLDSMOBILE 42
1915 WESTCOTT-U
1915 CADILLAC

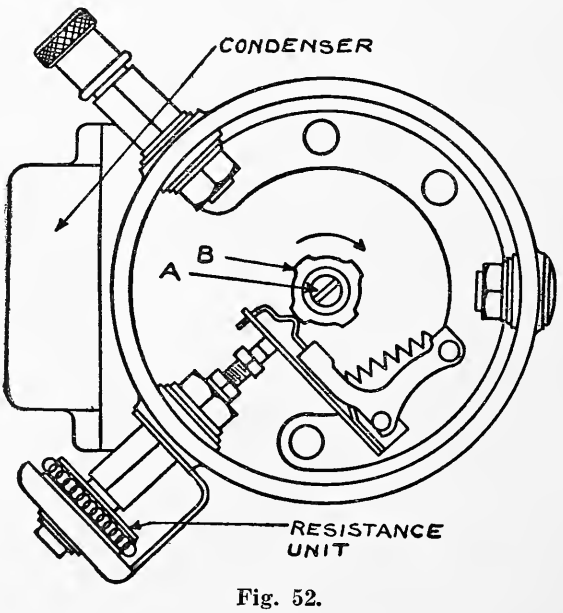


Fig. 52.
1915 COLE 4-40

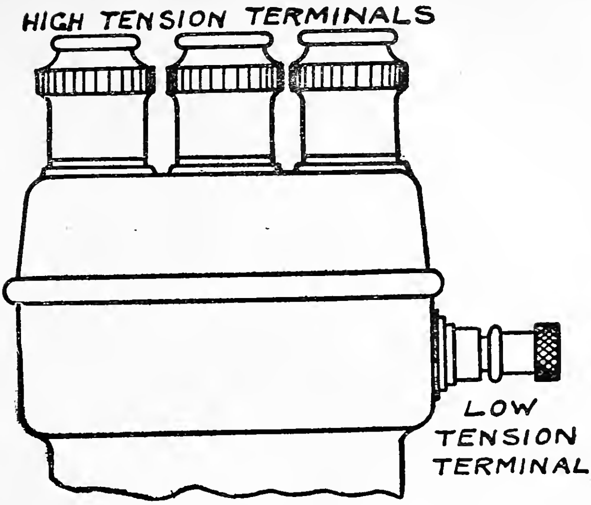


Fig. 56.

HIGH TENSION DISTRIBUTOR

This high tension distributor differs from the usual form of ignition systems in that it embodies in one unit a timer, means of advancing and retarding the spark, and a high tension distributor. It requires but one induction coil for any number of cylinders. The high tension wires are connected from their respective cylinders to the terminals of the distributor. The connection to the distributor terminals is made by peeling the insulation off of the high tension wires back about 3⁄8 of an inch and inserting the bare wire through the hole in the terminal and spreading it on the under side. When the terminal cap is screwed down the wire is securely clamped and cannot get loose.

INSTALLING AND ADJUSTING DELCO TIMER CONTACTS

All of the Delco timer contact points with the exception of the battery points used in the dual distributors are tungsten metal, which has a very high melting point, and is too hard to file. These will burn but very slightly when conditions are normal, but with improper or shorted out resistance unit, or a defective condenser or improper voltage (such as is secured by running the car without a storage battery) they will burn and pit very rapidly. Whenever burned or pitted, they should be dressed so as to give a smooth, flat surface across the face. This can be done by holding in a vise and using fine emery cloth under a flat file. Care should be taken to dress these perfectly square. If they are burned too much to permit the proper dressing, they should be replaced by new ones. After they are put in position and adjusted, as shown in Fig. 59, the ignition resistance unit should be tested as follows: Close the "M" ignition circuit and, with the distributor head and rotor removed, bring the timer contacts together, at which time the resistance unit should heat up sufficiently in 30 seconds' time to make a drop of oil placed on it smoke.

If the resistance unit does not heat up properly, it is either shorted out or the circuit is open at some other point, or the storage battery is completely discharged. The resistance unit should always be tested in this manner, because if it is shorted out, the timer contacts will burn very rapidly, the ignition will be poor at low speeds, and the ignition coil and condenser are subjected to abnormal voltages, which are very apt to result in damage to either or both in a short time.

After making sure that the resistance unit is in the circuit properly, observe the action of the contact points while the starter is cranking the engine. If a decided spark occurs each time the contacts open, a broken-down condenser is indicated, which, of course, should be

replaced by a new one. A very small spark may sometimes be observed even with a good condenser.

Care must be taken to see the pig tail (that is, the flexible stranded wire) is held firmly by the screw that holds the contact stop arm. If the pig tail is not properly secured, the contact pivot will sooner or later become burned and stick, due to the ignition current being carried through the pivot.

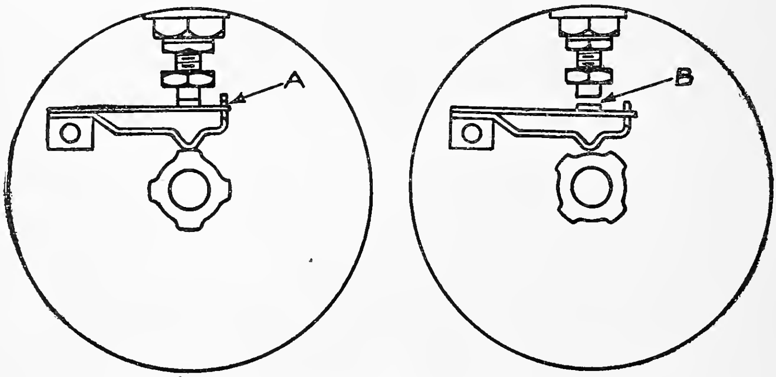


Fig. 59.

CONTACT MAKER ARMS AND ADJUSTMENTS

To adjust the distributor contact note the following instructions: When contact arm is directly on top of lobe of cam the distance between points "A," Fig. 59, should be about fifteen thousandths of an inch. When the lobe of cam of timer has broken contact with the contact arm, the distance between the points "B," Fig. 59, should be about ten thousandths of an inch. These distributors are constructed to care for battery or magneto ignition, or both, as the case may be.

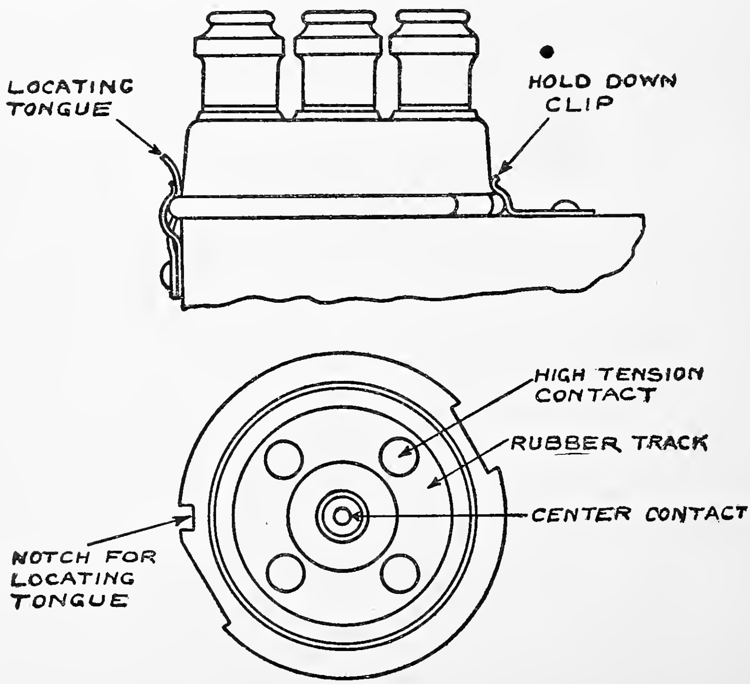


Fig. 60.

INSTALLING DISTRIBUTOR HEADS

All the Delco distributor heads are now fitted with a rotor track of hard rubber compound especially developed for this purpose. This overcomes the burning of the distributor heads which occasionally occurred at this point in the bakelite heads and which resulted in faulty ignition. At the time of installing the new distributor head the breaker contact points should be checked up as given under "Installing and Adjusting Delco Timer Contacts." Also the condenser should be checked as described under "Instructions for Installing Condenser." It is important that the distributor head be held firmly in place by the hold-down clips shown in Fig. 60. If necessary, bend these clips to hold the head firmly. Also the locating tongue on the distributor must be in the notch in the distributor head provided for it. Otherwise the rotor button will not be in contact with the high tension terminal in the distributor head at the time the spark occurs, which will cause burning of the head and poor ignition. The distributor head should be kept clean. All dust and dirt should be wiped from the interior with a soft cloth and vaseline applied as described in connection with the rotor.

ROTORS

The important features concerning the rotor are:

(1) That this rotor button is polished smooth and bright. If not to subject the rotor button to undue pressure on the distributor head.

(2) That this rotor button is polished smooth and bright. If necessary, burnish this button by first using fine emery cloth, then a piece of cloth or leather. The idea is to have the button polished bright so as not to cut the distributor head and high tension contacts, the dust from which causes a conducting path in the distributor head which causes a spark to be carried to the improper terminal and results in burning of the distributor heads.

(3) Occasional lubrication of the track of the distributor head by a particle of vaseline no larger than the size of a breaker contact may be necessary to prevent wearing by the rotor button, but grease or oil containing graphite must not be used for this purpose, as graphite is an electrical conductor.

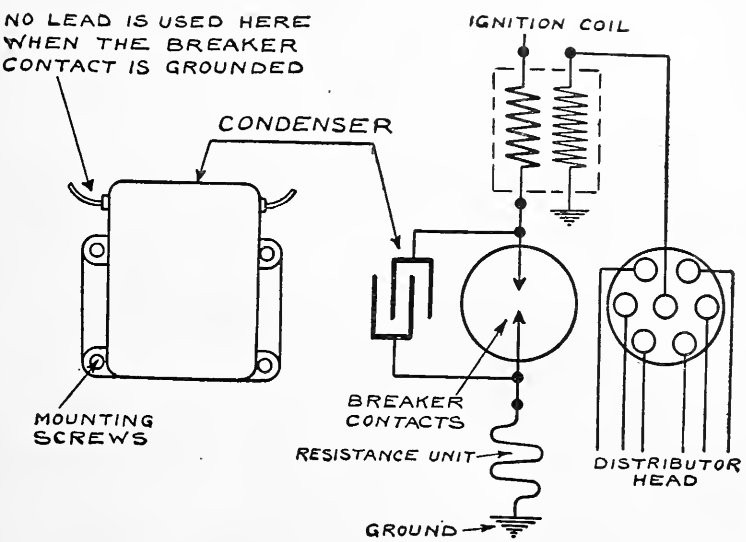


Fig. 61.

INSTRUCTIONS FOR INSTALLING CONDENSERS

A condenser consists of two strips of tinfoil separated from each other by paraffined or oiled paper with the necessary mounting and connections. When broken down a condenser causes poor ignition, usually irregular missing, and sometimes complete failure. If broken

down in such a manner as to cause irregular missing, the distributor contact breaker points will burn and slacken. This can be seen by removing the distributor head and rotor and observing the operation of the breaker contact when the starter is cranking the engine. If the condenser is at fault, there will be a decided spark each time the contacts open. (A slight spark will sometimes be noted even with a good condenser.) Whenever a condenser is installed the contact points should be carefully inspected, and if blackened or burned, they should be removed and dressed as described under the heading, "Installing and Adjusting Delco Timer Contacts."

Figure 61 shows a Delco Condenser and at the right is a circuit diagram of the ignition circuit, with the exception of the switch. A condenser is always connected across the timer contacts. In some systems the resistance unit is in the circuit between the ignition coil and the timer contacts, but this in no way changes the working of the system. Current does not flow through the condenser, but instead current flows into the condenser and back out in a reverse direction at the time the contacts open. It is this charging of the condenser that prevents the burning at the contact points and the discharging from the condenser that produces the high voltage from the ignition coil. Therefore, it is very evident that the condenser affects the contact points and the size and nature of the spark obtained from the ignition coil. All the late type condensers have a dull nickel finish.

IGNITION COIL

Ignition coil troubles may be separated into two classes. These are primary and secondary.

Primary troubles may be either open or grounded, either of which can be determined when the resistance is tested, as described under the heading, "Installing and Adjusting Timer Contacts." If the primary winding is grounded, the resistance unit will not heat up properly, though it may heat up partially, depending upon the nature of the ground. The most common method of grounding is by the coil being turned until one of the terminals comes in contact with the mounting bracket. If the primary winding is open, no current will flow through the resistance unit and it will not heat at all, but a loose connection may sometimes test as apparently good and only open when the car is vibrating. About the only satisfactory test for locating this is to have an ammeter in the circuit and observe the reading while the car is running.

Secondary troubles always result in a weak spark. This can be located by removing the high tension lead from the coil and observing the spark. With a defective secondary a weak spark will result. With a good coil the engine should fire regularly while the spark is jumping at least one fourth of an inch.

ADVANCE LEVERS

The connection to the advance lever on all distributors and generators should be so made that when the spark lever on the steering wheel is fully advanced the advance lever on the generator or distributor should not be advanced to its full movement.

If this lever is advanced to its full movement and is held in this position, it throws an undue strain on the advance mechanism, which causes unnecessary wearing on the distributor gears.

If the proper advance cannot be secured without advancing this lever to its full movement, the engine should be retimed, as there is ample advance provided in Delco distributors.

SPARK PLUGS

The best results from Delco ignition are obtained when the spark plug setting is thirty thousandths of an inch. This is approximately the thickness of the gauge on the distributor wrenches, though the ignition will work very satisfactorily with considerable variation from this setting.

No advantage is obtained by having more than one gap in a spark plug.

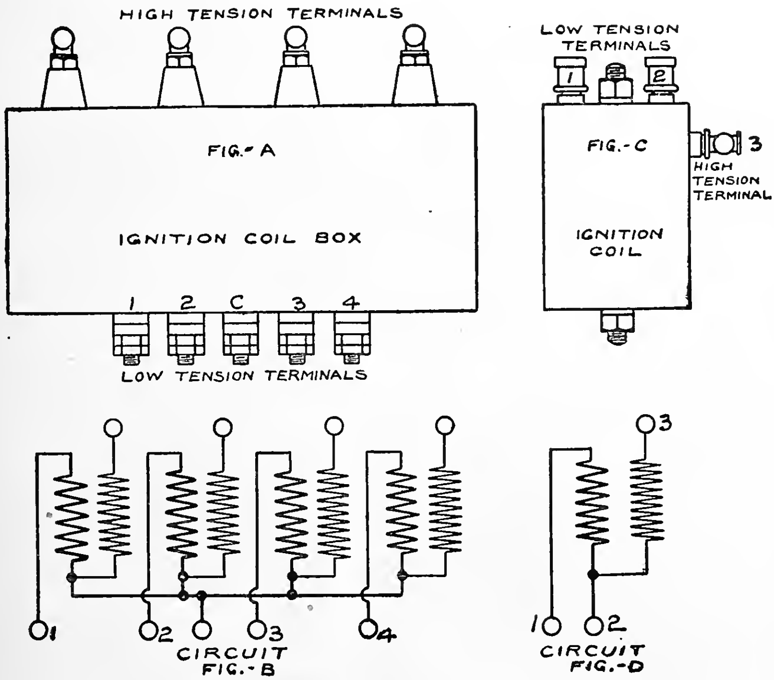
Electric adhesive tape should never be used around high tension wiring, as this contains sufficient conductive material to carry ignition current and often causes serious ignition trouble.

TIMING OF IGNITION

In general, the timing of Delco ignition is the same as a magneto. That is, the spark occurs when the contacts open, and this should occur at or near dead center on the firing stroke when the advance lever on the steering column is fully retarded. This method may be employed to time any Delco system when more complete timing instructions cannot be had, but it is always better to get the timing instructions from the general instruction book, as different engines require different timing, but the general timing can be outlined as follows:

1. Fully retard spark lever on the steering wheel sector.
2. Turn the engine to dead center with No. 1 cylinder on the firing stroke (practically one half a revolution after the intake valve closes).
3. Loosen the screw A, Fig. 52, in the center of timing mechanism and locate the proper lobe of the cam by turning with the rotor on the cam until the button on the rotor comes directly under the position the No. 1 high tension terminal in the distributor head will occupy when the distributor head is properly located.
4. Set the cam B, Fig. 52, so that when the back lash in the distributor gears is taken up clockwise the timing contacts will be open, and when the rotor is rocked backward to take up the back lash the contacts will just close.

(Caution: The dual distributors always time by the magneto contacts. These are the larger contacts.)



COIL BOXES AND IGNITION COILS

1910 Coil box. This unit contains four ignition coils (without vibrators), one for each motor cylinder. Fig. A shows the box with high and low tension terminals. The top of the terminal is designed to receive the "Connecticut," "Rajah," or regular type of terminal. The five terminals at the bottom are for the primary connections. The middle one is the common and connects with the zinc of the battery. The other four connect with the timer contacts. The internal circuits are shown in Fig. 8.

Ignition Coil. Fig. C shows the type of coil used on all Delco systems later than 1910. The internal circuit (Fig. D) shows one end of the secondary connected to the primary. This is used on all battery systems, and 1915 Cadillac. In all magneto systems and all dual systems except 1915 Cadillac the secondary is not connected to the primary in the coil, but is connected to the frame of the coil, therefore it is necessary in this case to run a wire from frame of coil to frame of car (ground). Note.—If this wire is omitted, the ignition will be defective. In case of doubt, ground the frame of the ignition coil, as no harm will be done should this be unnecessary.

IGNITION RELAY

This piece of apparatus is for the purpose of breaking the primary circuit and thereby producing a spark from the secondary windings of the induction coil. It takes the place of the four vibrators on an ordinary coil unit or simple coil system timer. In this way it replaces what is commonly known as a master vibrator. It differs from the ordinary vibrator, however, in that it uses but one spark for each contact of the commutator.

C is the magnet coil, composed of two windings: one heavy winding through which the primary circuit passes when the timer makes contact, thus drawing down the armature A, which swings on a rust-proof pivot at X and opens contact P. This contact opens the circuit and the armature would again return to its first position, making contact and breaking it again as an ordinary vibrator if it were not for a second fine winding, wound on the same coil, but shunted around P. The current flowing through this holds the armature A against pole piece PP until the timer slips off contact, when this auxiliary circuit is opened, thus releasing the armature and allowing the platinum iridium contact P to come together and be ready to break the circuit when the timer makes the next contact.

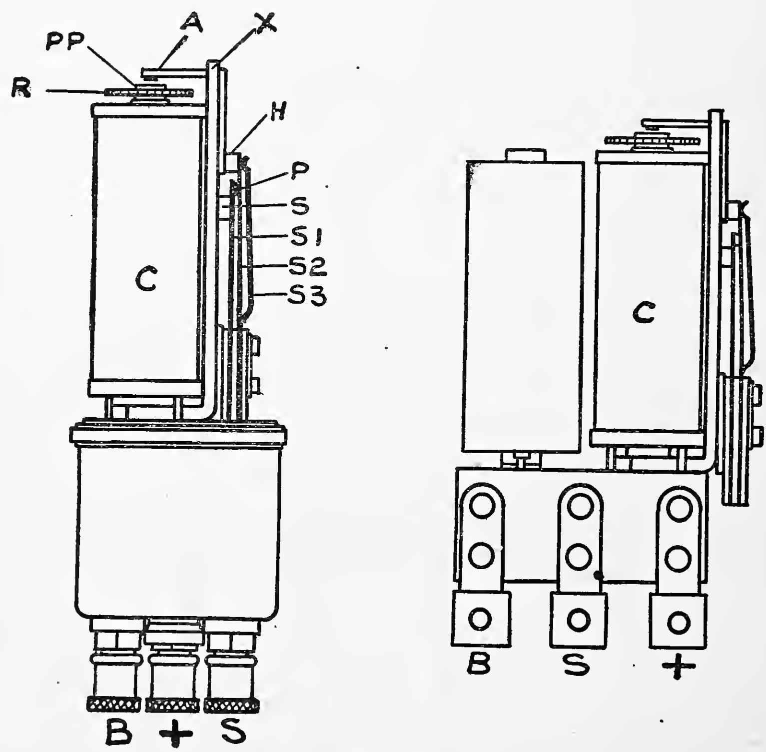


Fig. 62.

When the vibrator button on the switch is pushed on, it opens this auxiliary or holding coil and permits the armature to vibrate the same as any vibrator, sending a shower of sparks to the cylinder for starting.

S is a hard rubber spacing support which holds the lower contact spring in a definite position. H is a hard rubber insulating stud which, when the armature A is pulled down to pole piece PP, pushes the spring S2 and S3 away from the spring S1, thus opening the contact P.

PP is a pole piece which screws in or out as desired by means of a ratchet R. This is the only adjustment on the entire system and is only used to get the proper opening of the contacts P.

As this relay is unusual in construction, it is but natural that people should attribute almost every little trouble to it. Loose connections, grounded wires, and weak batteries make the relay work improperly, but through no fault of the relay itself.

The only point in the care of the relay which it should be necessary to watch is the pole piece adjustment. This should be set so that the opening between the contacts when the armature (A) is shoved down against the pole piece PP will be about the thickness of one sheet of the paper upon which this is printed. A simple way of determining this is to screw the pole piece outward—that is, in the direction opposite to the hands of a watch, until the motor stops firing. Then go the other way four or five notches.

Sometimes particles of dirt get between the armature and the pole piece at the point M. This will sometimes cause the armature to stick down when running the engine on the battery side, while it will still work with the button pushed in. This can be cleaned out by slipping a piece of paper between the pole piece and armature, pushing down lightly on the armature and pulling out the paper.

If the parts become bent, or if there is a reason to believe that the springs have become bent or are not of the proper tension, test as follows:

The spring S1 should be so adjusted that the rubber button "S" is held firmly against the upright, and the spring S2 should be so adjusted that the two platinum points at "P" are very lightly in contact when the spring S3 is held away from it; and the spring S3 should be so adjusted that it will press just hard enough against spring S2 so that when the primary timer is in contact and the switch lever is on the battery side of the switch and the push button is out, the vibrator will continue to vibrate when four common 1½-volt dry cells are connected, and should not vibrate when five common 1½-volt dry cells are connected.

The condenser is cylindrical in form, located beside the relay coil, and needs no attention.

SUGGESTIONS FOR THE CARE OF THE IGNITION RELAY

1. If for any reason a relay should need adjustment, follow carefully instructions given above. This adjustment is only to compensate for the wearing of the contacts and under no conditions should you screw the pole piece very far in or out. Screw it carefully one notch at a time, and remember the number of notches turned, so you can return it to the original position if desired.

2. If it should vibrate rapidly on contact when the switch lever is on "Battery," the holding coil circuit is open somewhere. Test out the circuit. In emergency connect the two terminals on the relay marked B and S with a wire. This will stop the vibration if the trouble is outside the relay.

3. If it should vibrate freely under the same conditions, it indicates weak batteries or dirty timer.

4. If a cylinder should miss, do not look for trouble in the relay, because it acts in the same capacity for all cylinders; if it hits on one, it will hit on all.

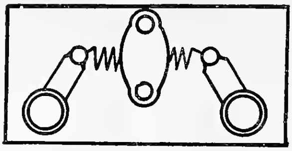


Fig. 63.

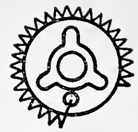


Fig. 64.

RESISTANCE UNITS

Figs. 63 and 64 show the two types of resistance units used.

This unit is in series with the magneto type ignition circuit, and, under ordinary conditions, the coil of special wire remains cool and offers little resistance to the passage of the current.

However, if for any reason the primary circuit of the magneto type ignition should remain closed for any length of time, the passage of current through the coil would heat it, thus increasing its resistance to a point where very little current could pass, insuring against waste of current and damage to the ignition coil and timer contacts.

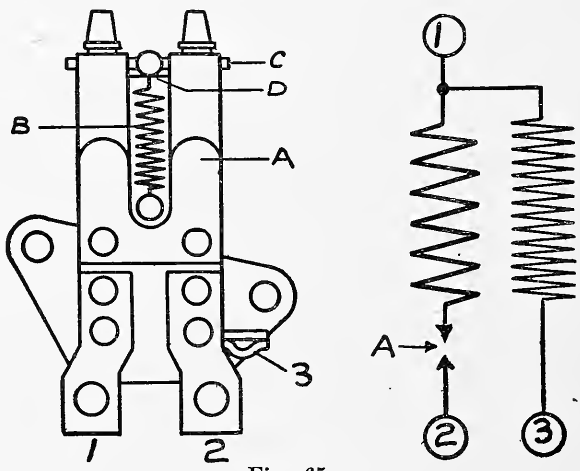


Fig. 65.

CUT-OUT RELAY

The cut-out relay is an electro-magnet with a compound winding. The voltage coil or fine wire winding is connected directly across the terminals of the generator. The current coil, or coarse wire winding, is in series with the circuit between the generator and the storage battery, and the circuit is opened and closed at the contacts "A."

When the engine is started the generator voltage builds up and when it reaches about six and one half or seven volts current passing through the voltage winding produces enough magnetism to overcome the tension of the spring "B," attracting the magnet armature "C" to core "D," which closes the contacts "A." These contacts close the circuit between the generator and storage battery. The current flowing through the coarse wire winding increases the pull of armature and gives a good contact of low resistance at the contact points.

When the generator slows down and its voltage drops below that of the storage battery, the battery sends a reverse current through the coarse wire windings, which kills the pull on the magnet armature "C." The spring "B" then opens the circuit between the generator and battery, and will hold it open until the generator is again started up.

Note.—Some relays have only two terminals. Where the No. 3 terminal is omitted the fine winding is connected to the frame of the relay instead.

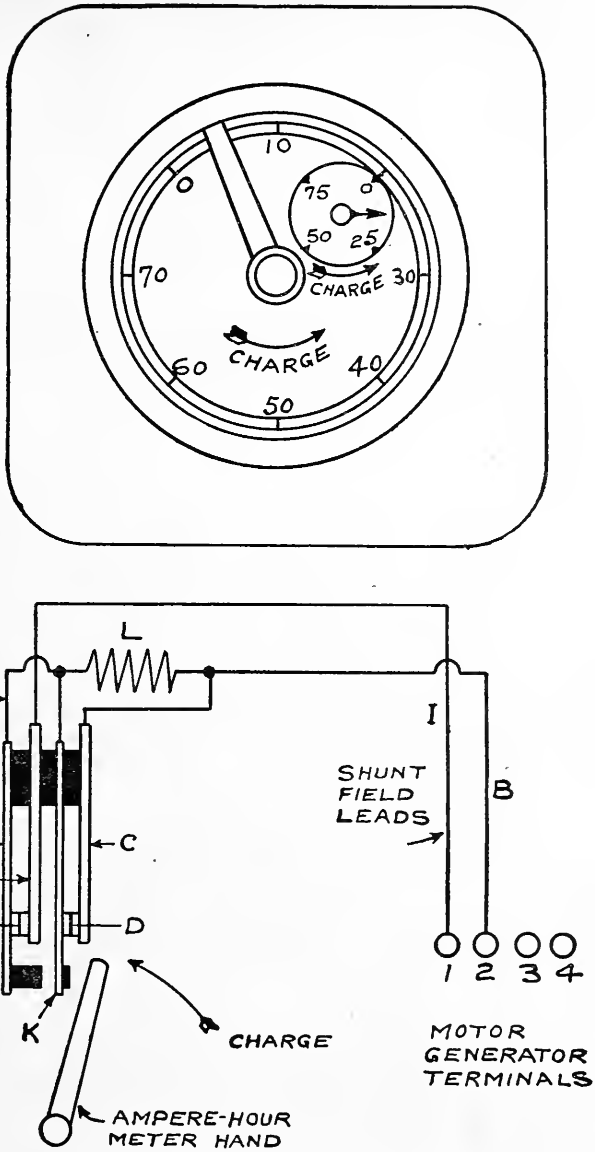


Fig. 66.

AMPERE-HOUR METER

The ampere-hour meter measures the current flowing into and out of the battery, but does not indicate the state of charge in the battery. The large hand on this meter runs clockwise when current is being taken from the battery and the opposite way when current is going into the battery. The little hand on this meter serves as an indicator, which enables one at a glance to determine whether the battery is idle, charging, or discharging. The meter contacts are on the side of the meter and serve as a means of opening the shunt field of the generator. This is accomplished by the large hand when it gets around to zero while the

battery is being charged. The only care of this meter is to lift the large hand and reset it back to "70" once every two weeks while filling each cell of the storage battery with distilled water.

Fig. 66 shows the ampere-hour meter contacts, and motor generator terminals. The current from the armature for the shunt field flows through line "B" into contact spring "C," through contacts "D" down through contacts "G," through contact spring "H," through the line "I," and back through the armature.

As the large ampere-hour meter hand rotates past "O," Fig. 66, it begins opening contacts "D" by pressing against contact spring "K."

When the contacts "D" are opened, the field current flows from line "B" through the resistance coil "L" to connection "E," instead of flowing through contacts "D." This cuts more resistance into the shunt field circuit of the generator, thus reducing the charge rate of the storage battery.

If the gasoline motor continues to run, the meter hand will continue pressing contact spring "K," which will engage with contact spring "F," opening contacts "G" and cutting off the charging current of the battery.

If the lights are turned on, or the engine cranked, the large meter hand will travel in the clockwise direction, gradually releasing contact spring "K" and closing contacts "G," which will cause the battery to be charged at a slow rate. If more current is consumed than is being delivered by the generator, the battery continues traveling in the clockwise direction, releasing all pressure on contact spring "K," which closes contacts "D," causing the battery to charge at its full rate.

The contact points at "D" and "G" should be examined occasionally to see that they are properly adjusted and making contact.

Once every two weeks the large hand on this meter must be set back 20 points in order to give the battery its overcharge. Never reset the hand past "70." To set the ampere-hour meter, disengage glass cover from bayonet lock, making sure to lift the large hand before trying to turn.

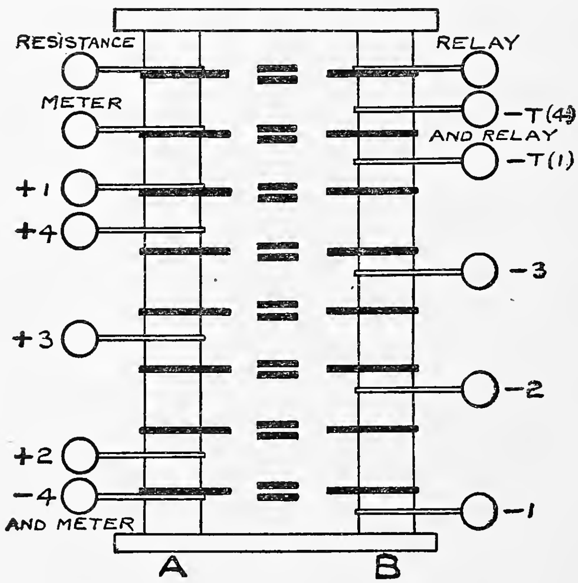


Fig. 67.

CONTROLLER SWITCH

The controller switch is an eight-pole double throw switch.

When the controller switch is in running position "A" it connects four 3-cell sections of

the storage battery in parallel, giving six volts, and also making the proper connection for lighting, magneto type ignition, and charging.

When the controller switch is thrown to position "B" this connects the four 3-cell sections of the storage battery in series, giving twenty-four volts and making the proper connections for cranking.

For owners who drive at very low speed, a special shunt wire will be furnished which will increase the charging rate of the battery. This resistance wire is connected between points Resistance and Meter.

Wipe off controller blades occasionally with a clean cloth.

THE MAGNETIC LATCH COIL

This is nothing more than an ordinary solonoid magnet coil and is connected in series with the starting switch and the motor. Its purpose is to prevent the engaging of the starting mechanism while the engine is running and to assist in engaging this mechanism when the engine is standing still. Note the following adjustments:

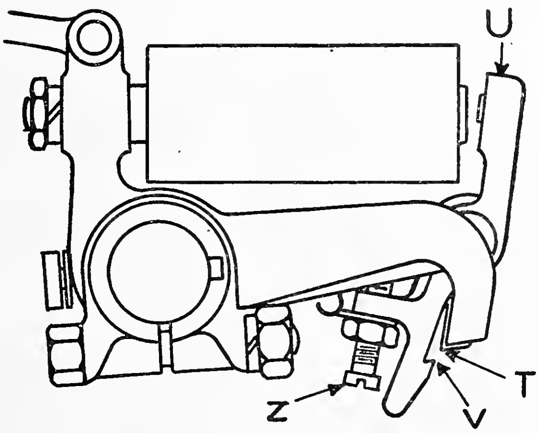


Fig. 68.

Adjustment of the Magnetic Clutch. The magnetic clutch arm U should be so adjusted by the adjusting screw Z that the arm T will pass the arm V, just allowing the points indicated by the arrows to clear each other when the main clutch is disengaged, and when the magnetic latch is in the disengaged position. Screwing up on the adjusting screw Z decreases the distance between points T and V. Unscrewing the adjusting screw Z increases the distance between these points.

VOLTAGE REGULATOR

The voltage regulator serves to control the amount of current flowing from the generator to the storage battery. Reference to Fig. 69 will assist in making the construction and operation clear. A magnet coil mounted on the top of the bracket surrounds the upper half of the mercury tube. Within this mercury tube is a plunger comprising an iron tube (core) with a coil of resistance wire wrapped around the lower portion on top of a mica insulation. One end of this coil resistance wire is attached to the tube (core) and the other end is connected to the needle in the center of the plunger. The lower portion of the mercury tube is divided by an insulating tube into two concentric wells, the plunger tube (core) being partly immersed in the mercury in the outer well and the needle immersed in the mercury in the inner well. The space in the mercury tube above the mercury is filled with a specially treated oil which serves to protect the mercury from oxidization and to lubricate the plunger.

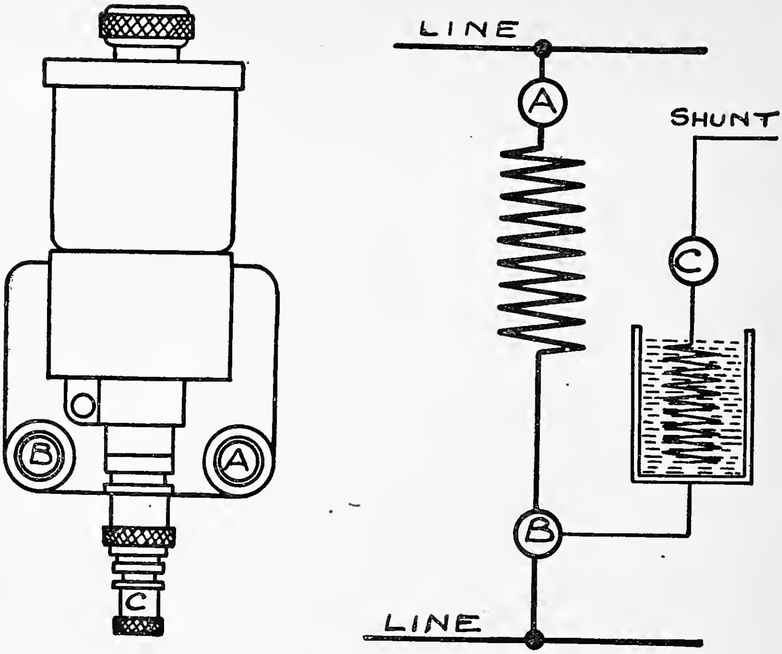


Fig. 69.

Inasmuch as the voltage of the battery varies with its condition of charge, the amount of current flowing through the voltage coil varies also. As the current flowing through the voltage coil increases, the plunger rises, and as the current decreases the plunger lowers. This is due to the variation in the magnetism produced by current flowing through the voltage coil. When the battery charge is low, the plunger assumes a low position in the mercury tube, and when the battery charge is high the plunger assumes a high position in the mercury tube when current is being generated. When the plunger is at a low position the coil of resistance wire carried upon its lower portion is immersed in the mercury, and as the plunger rises the coil of resistance wire is withdrawn from the mercury.

Now, the current to the shunt field of the generator must follow a path leading into the outer well of mercury, through the resistance wound on the plunger tube, to the needle carried at the center of the plunger, into the center well of mercury and out of the regulator.

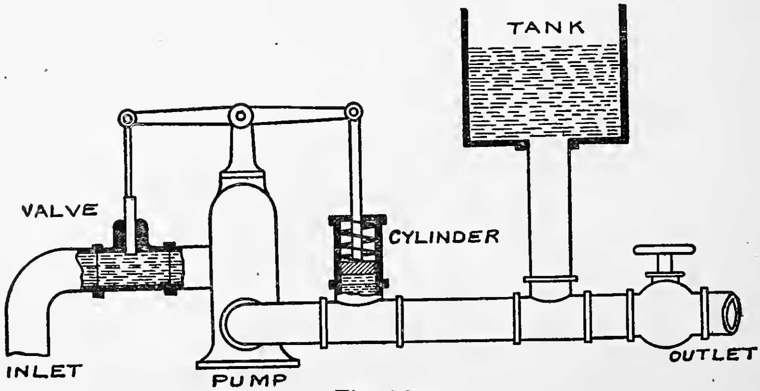


Fig. 70.

It will be seen that as the plunger is withdrawn from the mercury more resistance is thrown into this circuit, due to the fact that the current must pass through a greater length of resistance wire. This greater resistance in the field of the generator causes the amount of current flowing to the battery to be gradually reduced as the battery nears a state of complete charge, until finally the plunger is almost completely withdrawn from the mercury, throwing the entire length of the resistance coil into the field circuit, thus causing a condition of practical electric balance between the battery and generator, and obviating any possibility of overcharging the battery.

VOLTAGE REGULATOR

(Water Analogy)

To make the operation of the Voltage Regulator more easily understood, we give the following analogy:

When the tank (storage battery) is empty (discharged), little resistance is offered to the flow of water (current).

Small pressure (low voltage) is therefore required to overcome this resistance and force water (current) into the tank (storage battery) and the valve (plunger in tube) will remain wide open (set low in tube) allowing a large quantity of water (current) to be pumped (generated). As the water (current) continues to flow into the tank (storage battery) the pressure on the line increases, and this pressure acting through the pressure cylinder (voltage regulator coil) closes the valve (lifts the plunger out of the mercury) and decreases the flow of water (current). When the tank (storage battery) is about full of water (fully charged) the valve is nearly closed (plunger nearly all out of the mercury) and only a small amount of water (current) is pumped (generated).

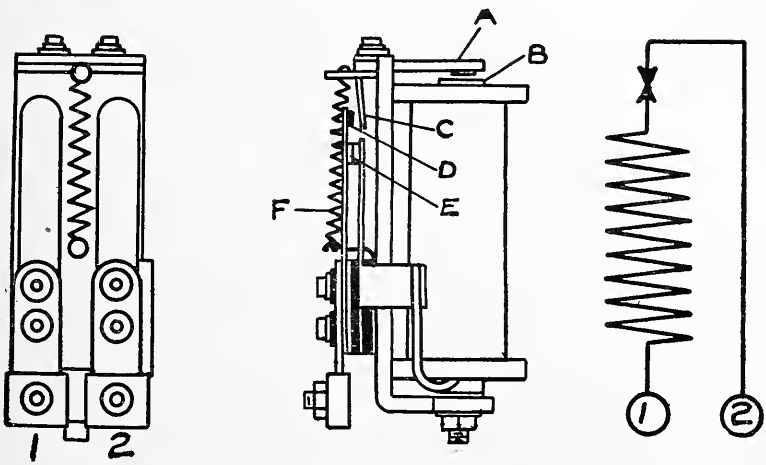


Fig. 71.

CIRCUIT-BREAKING RELAY

The circuit-breaking relay is an electro-magnet with a single winding. It opens and closes the circuit leading to the lamps, heater unit, horn, and ignition apparatus at contact "E."

When a ground or short circuit gets on one of the wires, it causes an excessive flow of current, which goes through the winding of the circuit-breaking relay. The increased current produces a magnetic pull between the pole piece "B" and the armature "A," which in turn causes the extension "C" of the armature "A," which in turn causes the extension "C" of the armature to give a hammer-blow effect on the point "D," which opens the contact "E" and cuts off the current supply. The opening of the contact kills the magnetic pull between the pole piece "B" and armature "A" and the contacts close again, but are opened as soon as the contact is made.

The relay will continue to vibrate until the ground or short circuit is removed.

A current of approximately 25 amperes is required to trip the circuit-breaking relay, but after it is in operation a current of approximately 5 amperes will cause it to continue vibrating until the ground or short circuit is removed.

The use of the circuit-breaking relay is the same as that of the fuse block and fuse, except that it eliminates the necessity of replacing fuses.

The relay will require no adjustment. Do not attempt to increase the tension of the spring "F" to overcome short circuits or grounds. Remove the short circuit or ground from the system and the relay will operate properly.

CURRENT REGULATOR ON COLE 4-40

The current regulator, which is mounted on the top cover of the motor generator, consists of a magnet coil and pivoted armature carrying a contact on the upper end.

The coil consists of three windings, one of which is a heavy wire and carries the full output of the generator which produces the major magnetic attraction for opening the contacts. The second winding is very small wire connected across the tungsten contacts, and is shown in the circuit diagram, Fig. M, page 165, in which the current flows only when the contacts are open and is so connected that its magnetic effect opposes the magnetic effect of the heavy winding. The third winding consists of comparatively few turns of resistance wire, which is also connected across the contacts. This is for the purpose of carrying the major part of the field current when the contacts are open.

Its Purpose. The purpose of the current regulator is to control the charging current. It does this by controlling the current through the shunt field winding, which in turn controls the magnetic field of the generator, and therefore the output or charging rate.

Its Operation. The tungsten contacts are held together by the spring against the magnetic attraction of the charging current flowing through the coil until this current reaches the value at which the regulator is set, this having been established at approximately fifteen amperes; the charging current will reach this value at from 600 to 700 R. P. M. of the generator. At higher speeds the contacts open and insert resistance in the shunt field circuit, which decreases the output of the generator, which in turn allows the contacts to close and the operation is repeated, causing the contacts to vibrate very rapidly—in fact, the vibration is so rapid that it is invisible to the eye, but it must not be understood that the regulator is not working because this vibration is invisible and at the higher speeds the contact points remain open, at which time sufficient field current is conducted through the fine winding and the resistance winding to allow the generator to deliver a full charging current, and the contacts are not subjected to any wear at this time.

On account of the fact that there is very little current conducted through these contacts at any time, and that no current is conducted through them at high speeds, and that no sparking is possible, there is practically no wear on them. Therefore, the adjustment remains permanent and no adjusting of this regulator is necessary. The original adjustment positively must not be changed without having an ammeter in the charging circuit and checking the charging current, as attempted adjustment without an ammeter may result in serious damage.

CHARGING A STORAGE BATTERY FROM AN OUTSIDE SOURCE

Fig. 72 shows method of charging a storage battery from an outside source with direct current. If only alternating current is available a rectifier must be used.

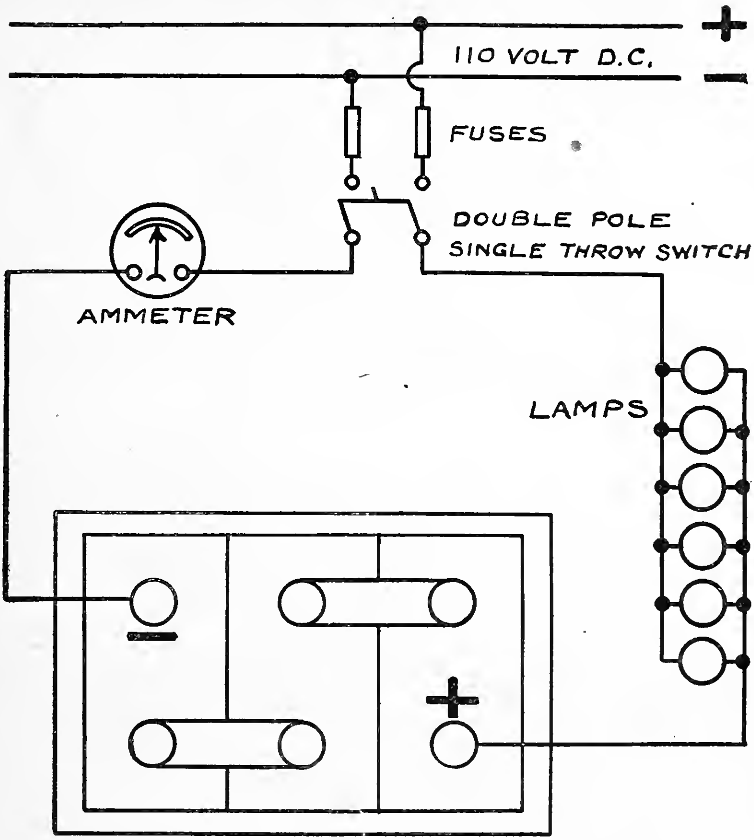


Fig. 72.

INDICATION OF TROUBLES AND THEIR REMEDIES

1. Failure to turn over at uniform speed when starter button is depressed.
2. Blackening and burning of the generator commutator.
3. Failure to keep battery charged.
4. Slow cranking, even with a well-charged battery.
5. Cut-out relay vibrates.
6. Excessive heating of the generator.

METHOD OF TESTING OUT THE ARMATURE

If any of the above indications exist, first see that all connections are complete and made correctly in accordance with wiring diagram.

Observe if the commutator has the same appearance all the way around or whether some of the segments are burnt more than others. See whether it will turn over uniformly when the starter button is depressed. If the generator commutator is burnt black on two or more adjacent segments, and it revolves unevenly when the starter button is depressed, it will almost invariably indicate that one or more of the armature coils are shorted, which will entirely eliminate the action of the winding in question so that the armature will revolve only for a fraction of a revolution. First, it will usually cause the relay to vibrate while the

engine is running. If an ammeter is connected into the circuit, it will swing back and forth at each revolution, both when the engine is running and when the starter button is depressed. If this condition exists, the winding of the armature may be tested as follows:

TO TEST FOR GROUNDS IN ARMATURE WINDING

In order to make the following test, it is advisable to use a 110-volt circuit in series with a 16-candlepower carbon filament lamp. The test may be made with the generator either mounted or taken from the car.

1. Insulate all brushes from the commutator by placing sheets of paper between them. Then with the test points, test for a ground from each commutator to the frame, as shown diagrammatically in Fig. 73. Neither commutator on either generator or motor winding should show a ground.

2. With the brushes and commutator bars insulated, as in the first test, try for connections between the armature and generator winding, holding one test point on a segment of the motor commutator and the other on the generator commutator. There should be no connection between the two windings and no grounds indicated.

If the motor fails to crank when the battery tests up to normal specific gravity, turn on the head lamp and operate the starting lever. If the lights go out, it indicates a bad cell

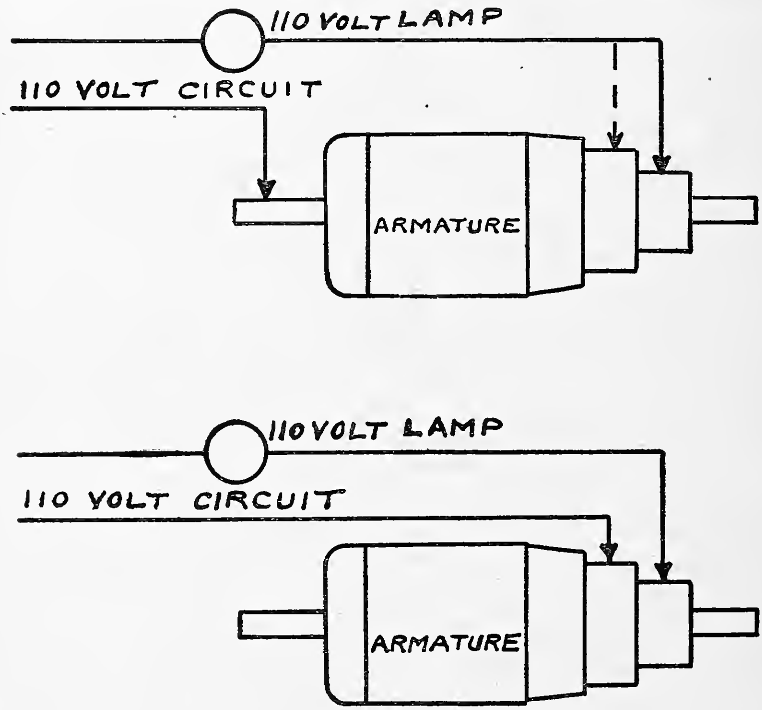


Fig. 73.

in the storage battery or a loose or poor connection either in the cell connectors or at one end of the large cable leading from the battery to the generator. If the light continues to burn but the motor makes no effort to crank, it is caused by poor contact between the motor brushes and commutator either due to accumulation of dirt or grease, or else to improper spring tension on the motor brushes. When this condition exists, added pressure such as will result from pressing the brushes firmly against the commutator with the fingers will usually result in the armature turning over, proving the contentions as above.

FAILURE OF THE CUT-OUT RELAY TO OPERATE

If the cut-out relay points stick, the generator armature will continue to revolve when the engine is stopped. Smooth the contacts by drawing a piece of fine emery cloth between them and make sure that the pivot is free mechanically. This is usually all that is necessary, although a sticking roller driving clutch at the forward end of the generator may cause a flow of sufficient current through the relay to give a similar result, and should be taken into consideration.

Before adjusting the spring tension, connect a voltmeter between the terminal No. 1, Fig. 74, on the cut-out relay, and the ground. With the engine running very slowly, gradually increase its speed, and if the spring tension is correct, the relay contacts will close when the meter indicates 7 volts. If the relay does not close the contacts at 7 volts, adjust the spring tension until it does. This may be done by slightly bending the arm at the top and to which the spring is attached, using a small pair of pliers for this operation.

INDICATIONS OF VOLTAGE REGULATOR TROUBLES

1. The generator will not turn to mesh the gears when the starter button is pressed, and
2. The generator will not generate.

The two indications go hand in hand in all cases.

In order to test for and remedy the above difficulties, proceed as follows:

Depress starter button and if armature does not revolve, remove the lead to the bottom terminal and voltage regulator tube, and connect the same lead to the terminal above, as indicated in Fig. 74. The armature will now revolve when the starter button is depressed. In order to make repairs, replace the regulator tube complete.

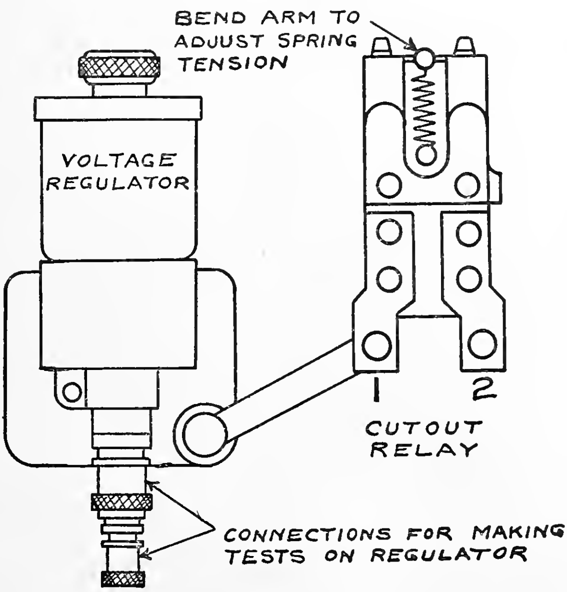


Fig. 74.

It is also well to check this out in another way, namely, by allowing the engine to run, and observing whether at normal speed the cut-out will remain open. This will also indicate a burnt-out voltage regulator resistance.

Under these same conditions if the lead connecting to the binding post at the bottom of the tube is moved up to the upper connection as before referred to, the cut-out will immediately be drawn closed and the generator will start to charge the battery.

INDICATIONS OF IGNITION COIL TROUBLES

Failure of spark or poor spark on both battery and magneto circuits.

To test the coil, close the switch on the magneto side and turn motor over until the contacts on the magneto distributor breaker come together and observe if the small resistance unit on the distributor heats up properly. If it does heat up properly and all connections are correctly made and the entire primary circuit on the magneto side is intact, continue cranking over the motor and observe whether the breaker points separate and are properly set. Then remove the high tension lead from the coil and with the rotor and head in place note the condition of the spark that can be obtained from the coil when the starter is cranking the engine. If the spark is weak, it indicates either a defective coil or a defective condenser on the distributor.

Next, with the battery contacts on the distributor closed, and the ignition switch on the battery side, depress the starting button and observe the spark obtained from the coil. If the spark is weak and about the same as obtained in the test above, it indicates that the coil is defective and not the condenser on the distributor, but if the spark is apparently strong in this case it indicates that the condenser on the distributor is at fault.

In case of failure of both battery and magneto systems, the probable causes are as follows:

1. Depleted dry cells and storage battery.
2. Loose connections at switch. Loose connection at primary of coil or at the distributor.
3. Grounded dry battery or wiring of battery system.
4. Punctured rotor.

Test for Nos. 1 and 2 as above has already been explained.

Disconnect the dry battery wiring at the distributor, and if the ignition is satisfactory on the magneto side, test the battery system for a ground. No part of the system, including ignition relay and switch terminals, should be grounded.

ROTOR

If a punctured rotor exists, a good spark may be obtained at the high tension terminal of the coil, but a weak spark, or perhaps none at all, will result at the plugs.

To Test the Rotor: Remove the high tension lead from the distributor head, hold this lead against the contact brush on top of the rotor and hold the bottom of the rotor about ¼ inch from the engine. If a spark can be made to jump through the rotor to the engine, it shows that the rotor is punctured.

HINTS FOR LOCATING TROUBLE

1. If starter, lights and horn all fail, the trouble is in the storage battery or its connections, such as a loose corroded connection or a broken battery jar.
2. If the lights, horn, and ignition are all O. K., but the starter fails to crank, the trouble is in the motor generator, such as dirt or grease on the motor commutator, or the motor brush not dropping on the commutator.
3. If the starter fails to crank or cranks very slowly, and the lights go out or get very dim while cranking, it indicates a loose or corroded connection on the storage battery, or a nearly depleted storage battery.
4. If the motor fires properly on the "M" button, but not on the "B" button, the trouble must be in the wiring between the dry cells or the wires leading from the dry cells to the combination switch, or depleted dry cells.

If the ignition works O. K. on the "B" button and not on the "M" button, the trouble must be in the leads running from the storage battery to the motor generator, or the lead running from the rear terminal on the generator to the combination switch, or in the storage battery itself, or its connections to the frame of the car.

5. If both systems of ignition fail and the supply of current from both the storage battery and dry cell is O. K., the trouble must be in the coil, resistance unit, timer contacts, or condenser. This is apparent from the fact that these work in the same capacity for each system of ignition.

Caution: Never run the car with the storage battery disconnected, or while it is off the car. Very serious damage to the motor generator may result from such action.

Never remove any electrical apparatus from the car to make any adjustments without first disconnecting the storage battery. This can most conveniently be done by removing the ground connection.

A careful inspection can never do any harm, and it will often locate a bad case of trouble.

Remember, a loose, corroded or dirty connection on the battery can put the starting system out of commission.

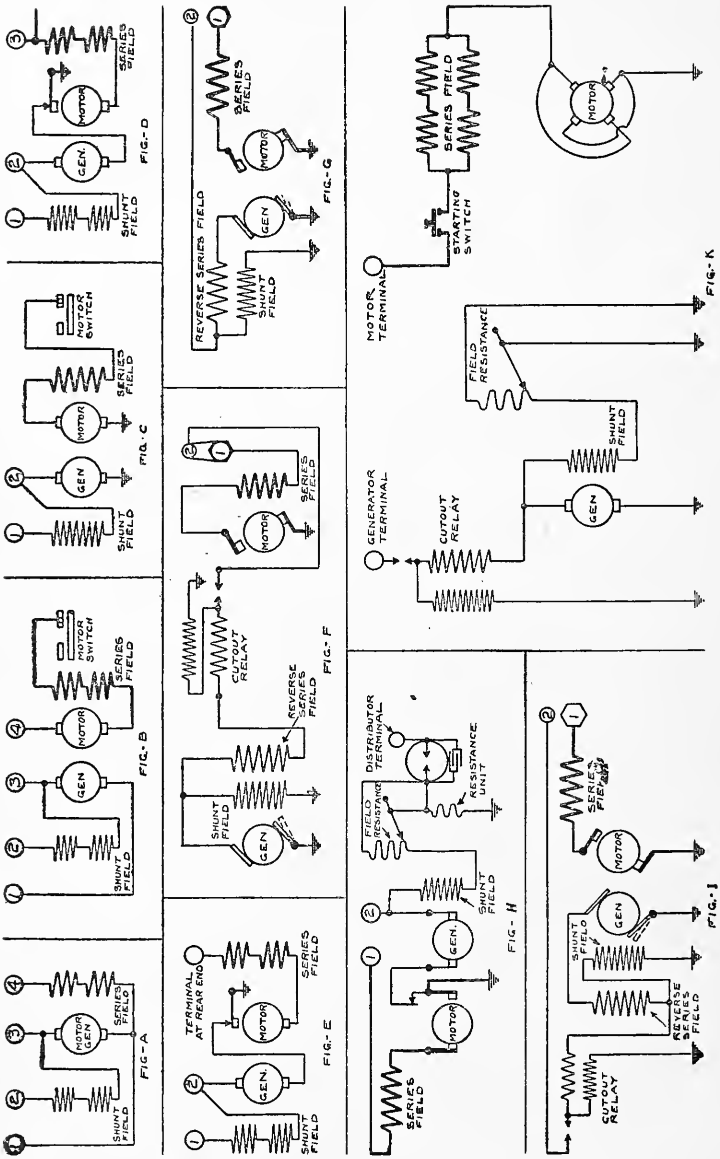
In wiring these systems follow the diagram closely and see that all connections are tight, and that no loose or frayed ends protrude from any of the connections, and that all joints in wires are carefully soldered and taped.

Do not place a wire so that some moving part of the engine will wear away the insulation.

If the system is not working properly, the first thing to do is to check up the wiring with the wiring diagram, and be sure all connections are tight.

The next thing to do is to make sure your batteries are all right. Sometimes wires become loose and batteries are short circuited, or they will run down in time even if not used.

Then, if the apparatus does need adjustment, follow the methods of adjustment as outlined in this book.



INTERNAL CIRCUITS OF MOTOR GENERATORS

(See Contents.)

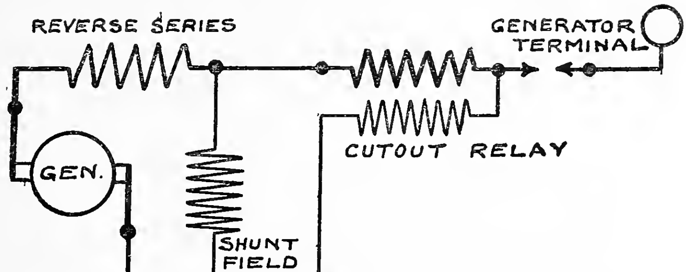


FIG.-L

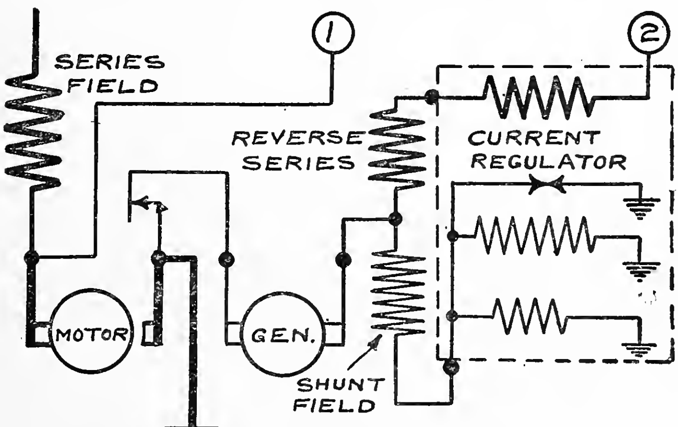


FIG.- M

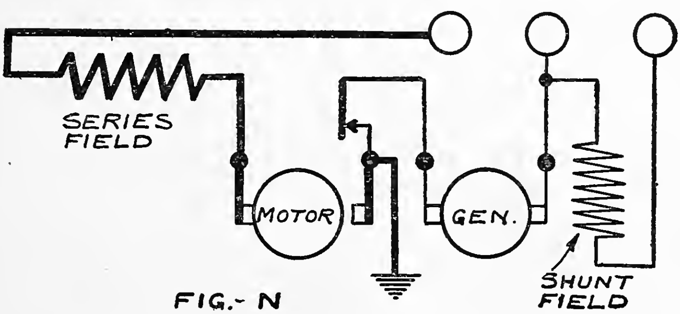


FIG.- N

INTERNAL CIRCUITS OF MOTOR GENERATORS
(See Contents.)

SECTION 5

1916 DELCO SYSTEMS

AND

INFORMATION ON THE FOLLOWING SUBJECTS:

Lubrication of Motor-Generators. Use of the Ammeter and How to Test It. Induction Coils and Methods of Testing Them. Distributors and Timers. How to Test Armatures. Motoring Generators. Generating Electrical Energy. New Third Brush Regulation. Resistance Unit and Method of Testing It. Checking and Timing of Ignition Systems. General Information. Ordering Parts.

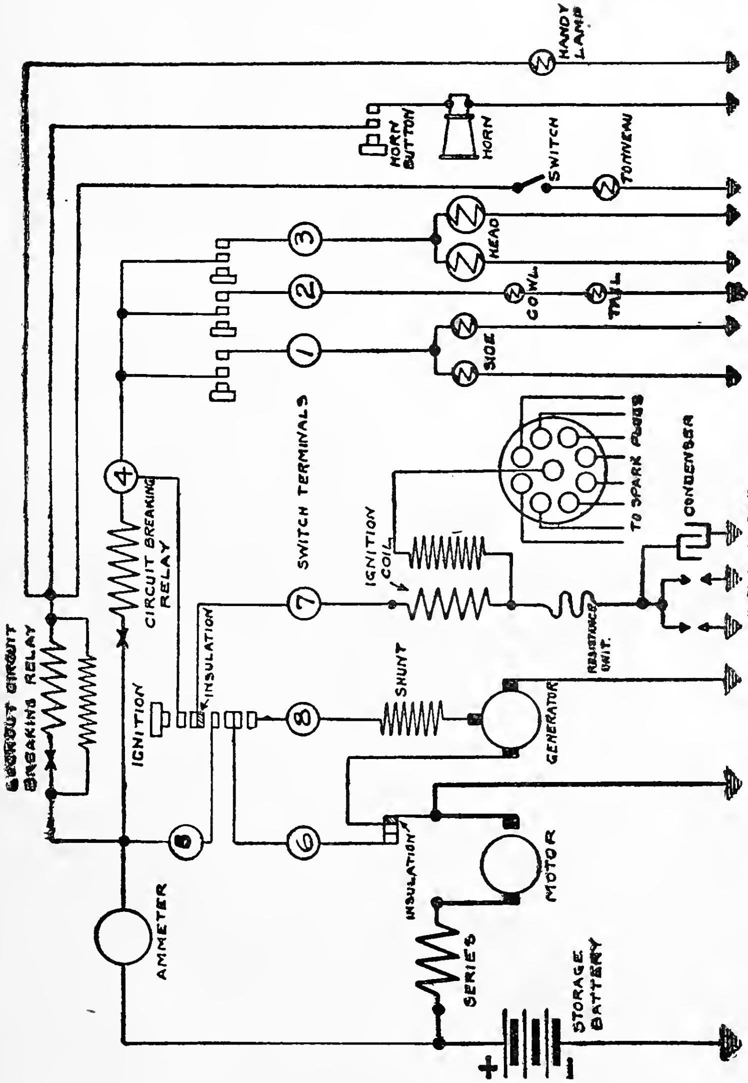

HANDY LAMP
HORN BUTTON
HORN
SWITCH
TONNEAU
HEAD
COWL
TAIL
SIDE
SWITCH TERMINALS
CIRCUIT BREAKING RELAY
IGNITION
INSULATION
IGNITION COIL
TO SPARK PLUGS
CONDENSER
DISTRIBUTOR
RESISTANCE UNIT
SHUNT
GENERATOR
MOTOR
INSULATION
SERIES
STORAGE BATTERY
AMMETER
1
2
3
4
5
6
7
8
+

Fig. 1.

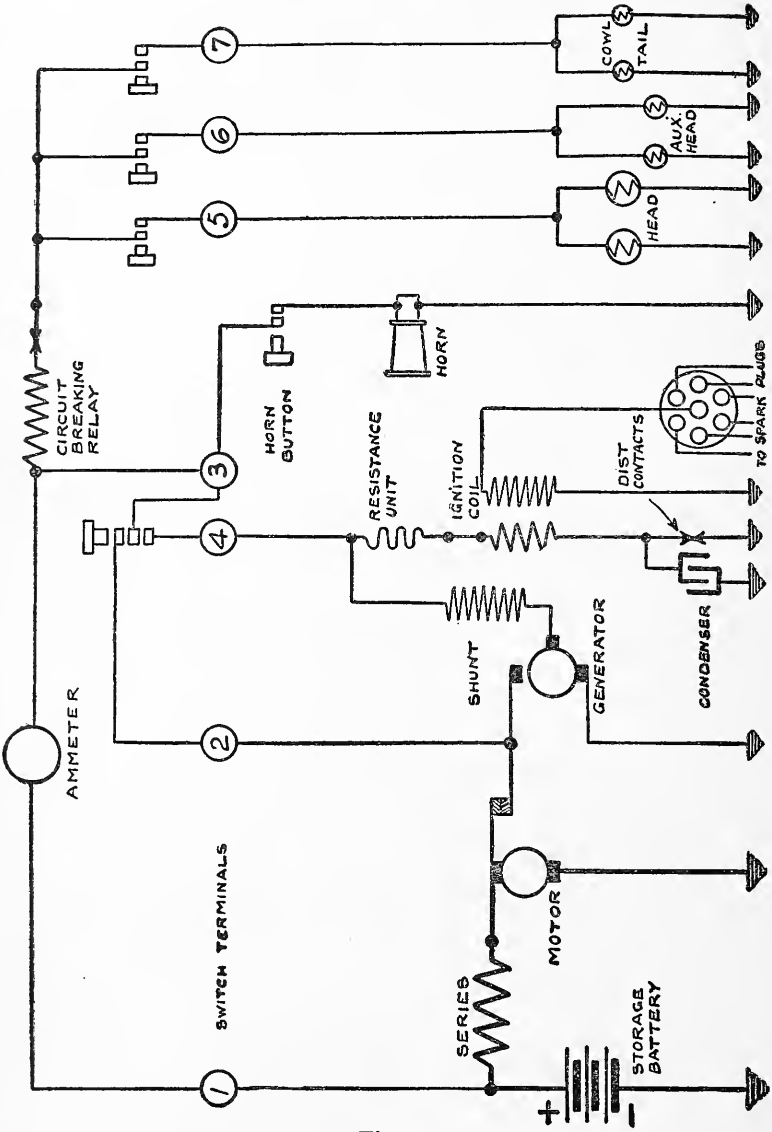

1
2
3
4
5
6
7
AMMETER
SWITCH TERMINALS
CIRCUIT BREAKING RELAY
HORN BUTTON
HORN
RESISTANCE UNIT
IGNITION COIL
DIST CONTACTS
TO SPARK PLUGS
DISTRIBUTOR
CONDENSER
SHUNT
GENERATOR
MOTOR
SERIES
STORAGE BATTERY
+
-
HEAD
AUX. HEAD
COWL
TAIL

Fig. 2.

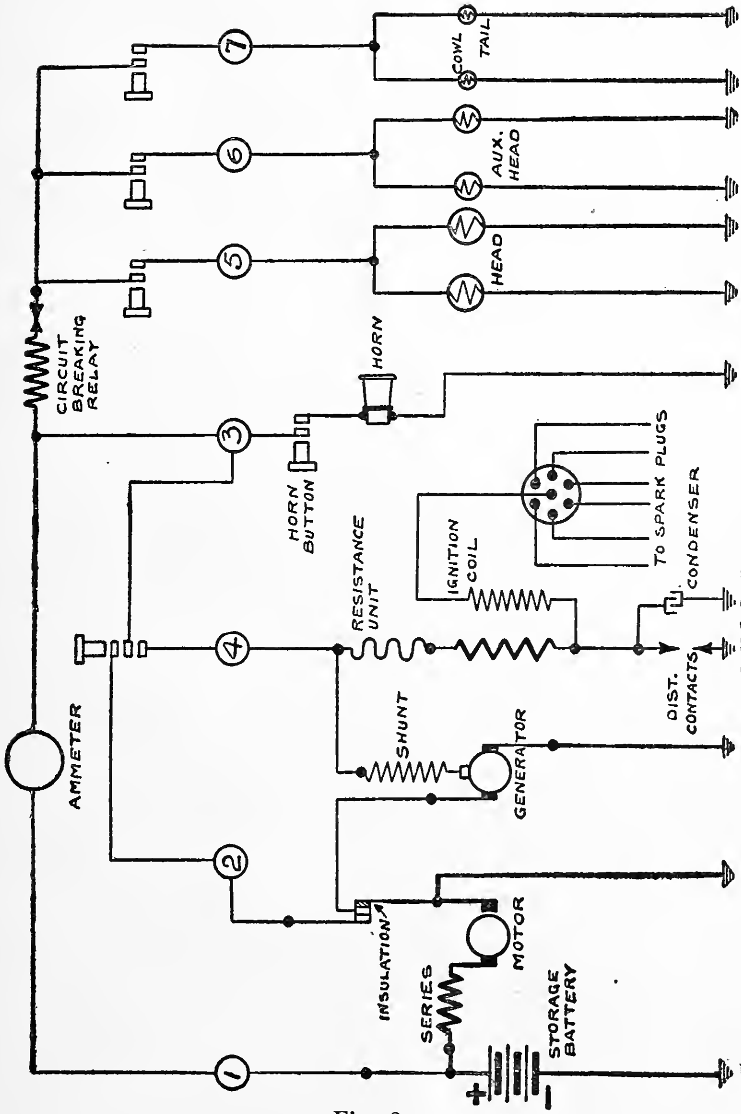

AMMETER
CIRCUIT BREAKING RELAY
HORN
HORN BUTTON
HEAD
AUX. HEAD
COWL
TAIL
RESISTANCE UNIT
IGNITION COIL
TO SPARK PLUGS
CONDENSER
DISTRIBUTOR
DIST. CONTACTS
SHUNT
GENERATOR
INSULATION
SERIES
MOTOR
STORAGE BATTERY
+
−
1
2
3
4
5
6
7

Fig. 3.

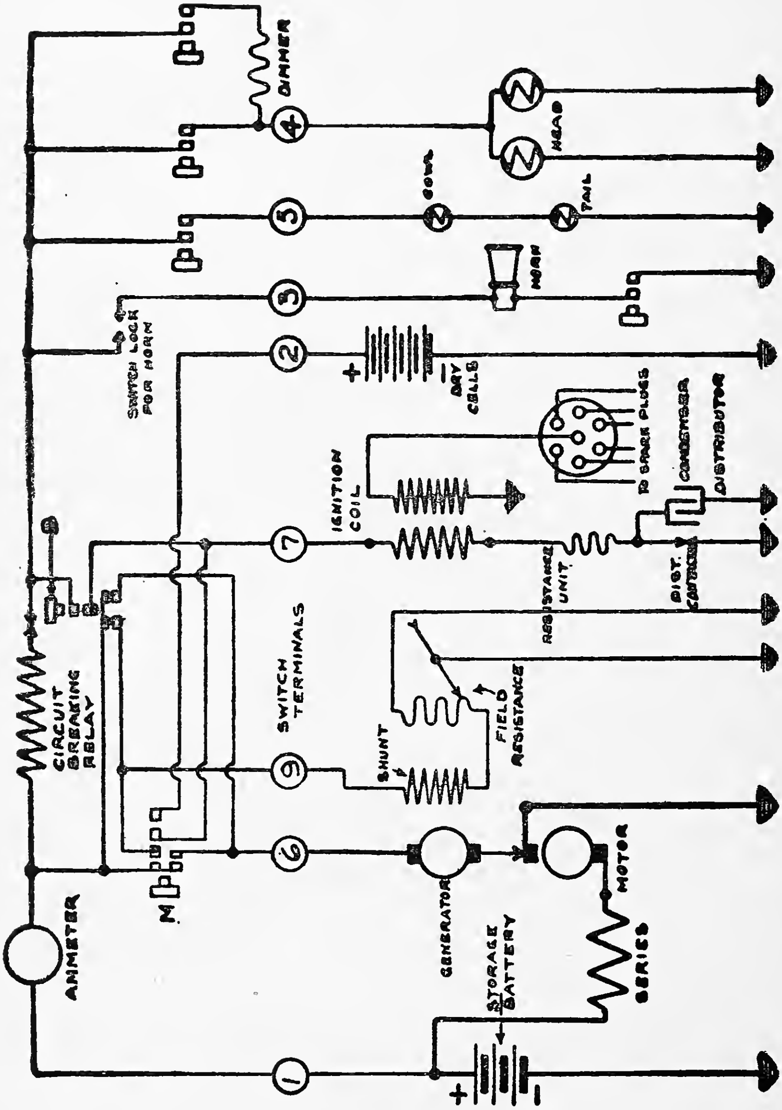

DIMMER
HEAD
COWL
TAIL
HORN
SWITCH LOCK FOR HORN
DRY CELLS
IGNITION COIL
CONDENSER
DISTRIBUTOR
SWITCH TERMINALS
CIRCUIT BREAKING RELAY
RESISTANCE UNIT
SHUNT
FIELD RESISTANCE
AMMETER
GENERATOR
MOTOR
STORAGE BATTERY
SERIES

Fig. 4.

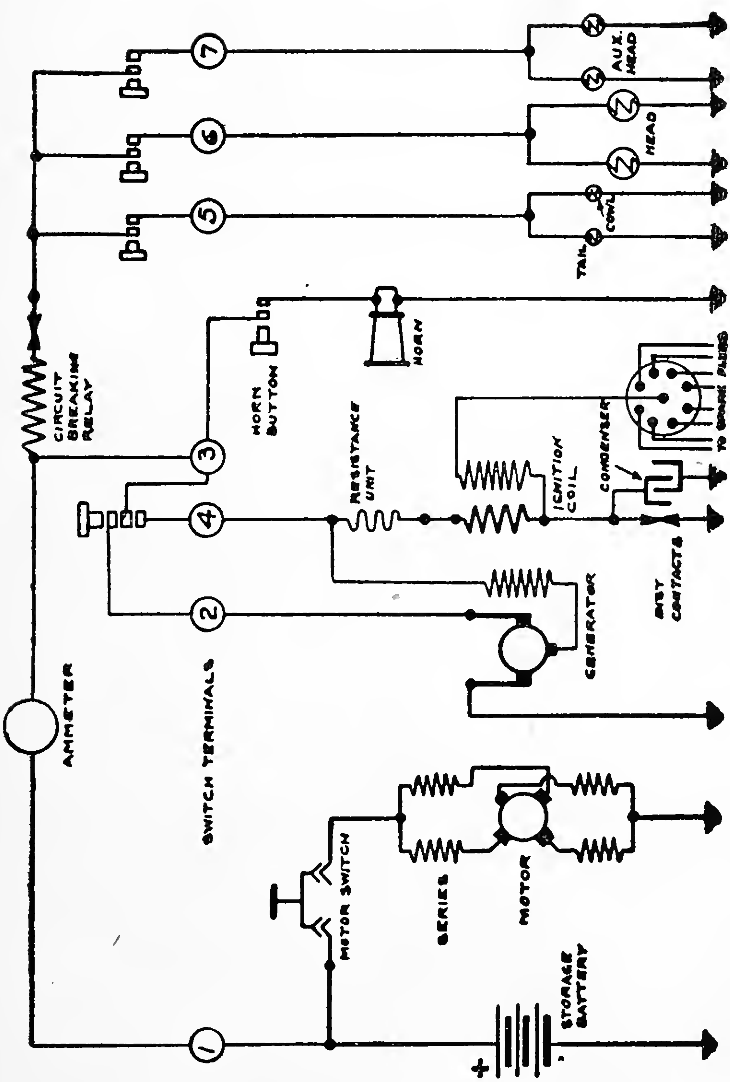

AMMETER
SWITCH TERMINALS
CIRCUIT BREAKING RELAY
HORN BUTTON
HORN
RESISTANCE UNIT
IGNITION COIL
CONDENSER
GENERATOR
SERIES
MOTOR
MOTOR SWITCH
STORAGE BATTERY
AUX. HEAD
HEAD
TAIL
COWL
CONTACTS
+
1
2
3
4
5
6
7

Fig. 5.

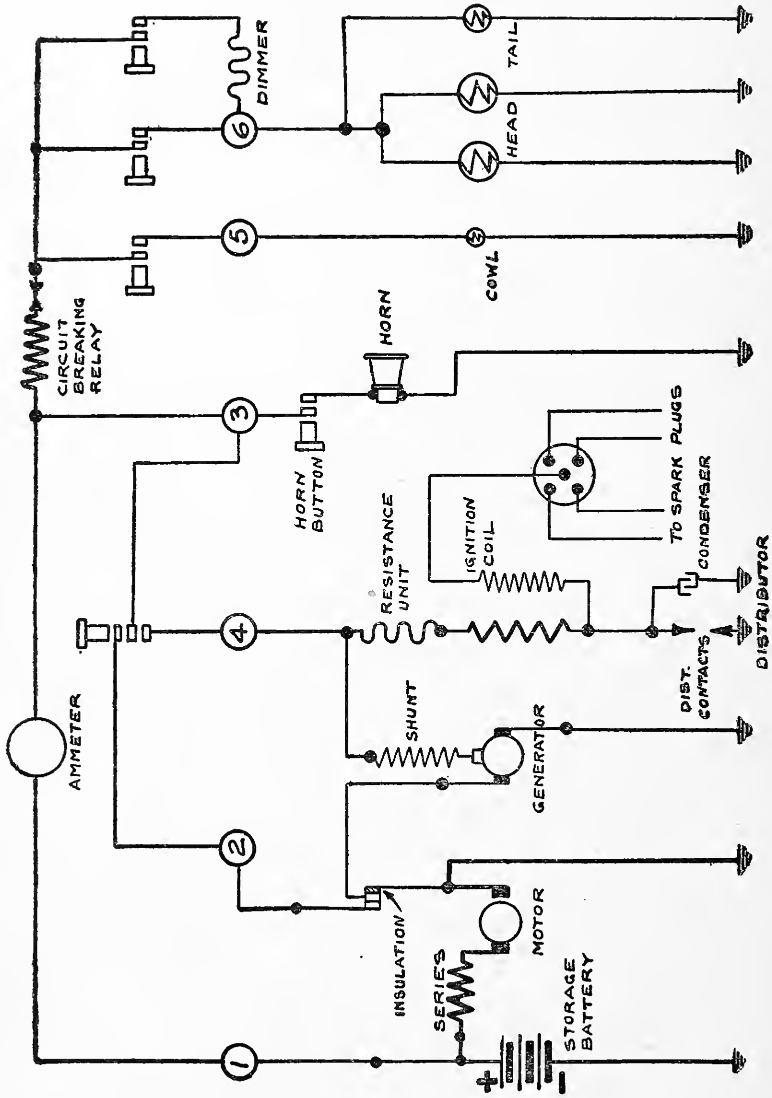

DIMMER
TAIL
HEAD
COWL
HORN
CIRCUIT BREAKING RELAY
HORN BUTTON
RESISTANCE UNIT
IGNITION COIL
TO SPARK PLUGS
CONDENSER
DISTRIBUTOR
DIST. CONTACTS
SHUNT
GENERATOR
AMMETER
INSULATION
SERIES
MOTOR
STORAGE BATTERY
1
2
3
4
5
6
+
-

Fig. 6.

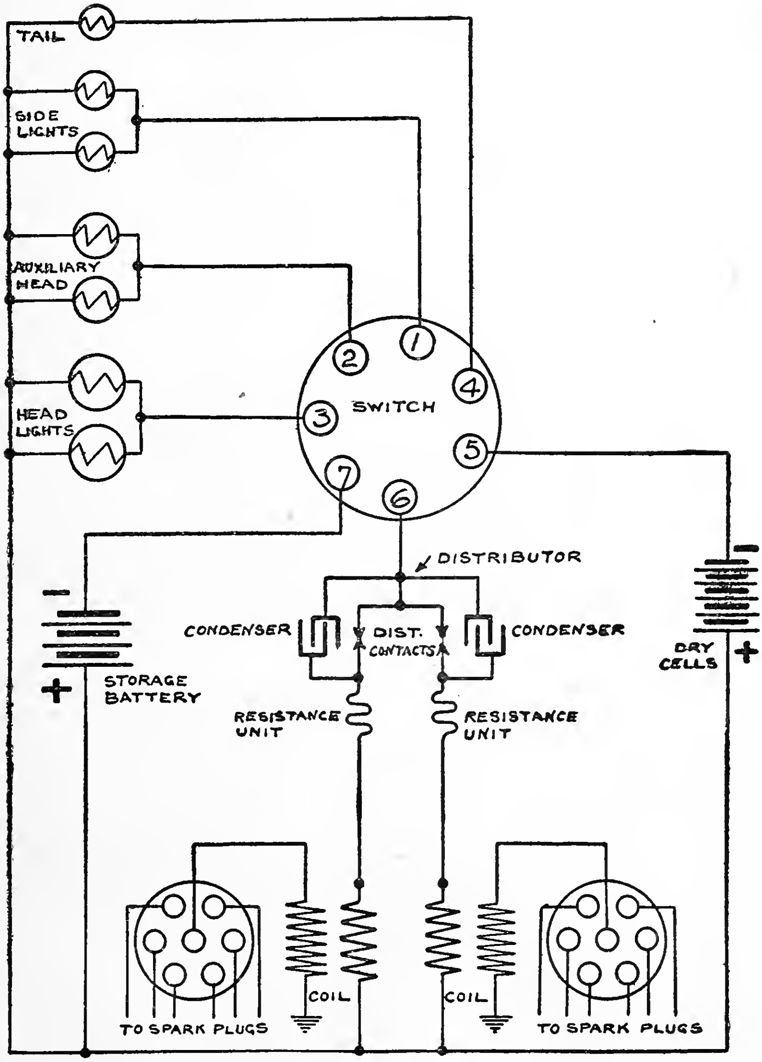

TAIL
SIDE LIGHTS
AUXILIARY HEAD
HEAD LIGHTS
SWITCH
1
2
3
4
5
6
7
DISTRIBUTOR
CONDENSER
DIST. CONTACTS
CONDENSER
DRY CELLS
STORAGE BATTERY
RESISTANCE UNIT
RESISTANCE UNIT
COIL
COIL
TO SPARK PLUGS
TO SPARK PLUGS

Fig. 7.

LUBRICATION

There are five places to lubricate Delco Systems.

No. 1. The grease cup for lubricating the motor clutch.

No. 2. Oiler for lubricating the generator clutch and forward armature bearing.

No. 3. The oil hole for lubricating the bearings on the rear of the armature shaft. This is exposed when the rear end cover is removed. This should receive oil once a week.

No. 4. The oil hole in the distributor for lubricating the top bearing of the distributor shaft. This should receive oil once a week.

No. 5. This is the inside of the distributor head. This should be lubricated with a small amount of vaseline, carefully applied two or three times during the first 2,000 miles running of the car, after which it will require no attention. This is to secure a burnished track for the motor brush on the distributor head. This grease should be sparingly applied and the head wiped clean from dust and dirt.

THE AMMETER

The ammeter is to indicate the current that is going to or coming from the storage battery, with the exception of the cranking current. When the engine is not running and current is being used for lights, the ammeter shows the amount of current that is being used, and the ammeter hand points to the discharge side as the current is being discharged from the battery.

When the engine is running above generating speeds and no current is being used for lights or horn, the ammeter will show charge. This is the amount of current that is being charged into the battery. If current is being used for lights, ignition, and horn in excess of the amount that is being generated, the ammeter will show a discharge as the excess current must be discharged from the battery, but at all ordinary speeds the ammeter will read charge.

IGNITION COIL

The coil proper consists of a round core or a number of small iron wires. Wound around this and insulated from it is the primary winding. It is the interrupting of the primary current that flows through the primary by the timer contacts, together with the action of the condenser, which causes a rapid demagnetization of the iron core of the coil that induces the high tension current in the secondary winding. This secondary winding consists of several thousand turns of very fine copper wire, the different layers of which are well insulated from each other and from the primary winding.

It is from a terminal about midway on top of the coil that the high tension current is conducted to the distributor, where it is distributed to the proper cylinders by the rotor.

DISTRIBUTOR AND TIMER

The distributor and timer, together with the ignition coil, spark plugs, and wiring, constitute the ignition system.

The proper ignition of an internal combustion engine consists of igniting the mixture in each cylinder at such a time that it will be completely burned at the time the piston reaches dead center on the compression stroke. A definite period of time is required from the time the spark occurs at the spark plug until the mixture is completely expanded. It is therefore apparent that as the speed of the engine increases the time the spark occurs must be advanced with respect to the crank shaft, and it is for this reason that the Delco Ignition Systems are fitted with an automatic spark control.

The quality of the mixture and the amount of compression are also factors in the time required for the burning to be complete. Thus a rich mixture burns quicker than a lean one. For this reason the engine will stand more advanced with a half-open throttle than with a wide-open throttle, and in order to secure the proper timing of ignition due to these variations and to retard, the spark for starting, idling, and carburetor adjusting, the Delco distributor also has a manual control.

With the spark lever set at the running position on the steering wheel (which is nearly all the way up on the quadrant), the automatic features give the proper spark for all speeds excepting a wide-open throttle at low speeds, at which time the spark lever should be slightly retarded. When the ignition is too far advanced it causes loss of power and a knocking sound within the engine. With too late a spark there is a loss of power (which is usually not noticed excepting by an experienced driver or one very familiar with the car); heating of the engine and excessive consumption of fuel is the result.

The timer contacts and their adjustments are two of the most important points of an automobile. Very little attention will keep these in perfect condition. These are tungsten metal, which is extremely hard, and requires a very high temperature to melt. Under normal conditions they wear or burn very slightly, and will very seldom require attention; but in the event of abnormal voltage, such as would be obtained by running with the battery removed, with the ignition resistance unit shorted out, or with a defective condenser, these contacts burn very rapidly, and in a short time will cause serious ignition trouble. The car should not be operated with the battery removed.

It is a very easy matter to check the resistance unit by observing its heating when the ignition button is out and the contacts in the distributor are closed. If it is shorted out it will not heat up, and will cause missing at low speeds.

A defective condenser such as will cause contact trouble will cause serious missing of the ignition. Therefore any one of these troubles are comparatively easy to locate and should be immediately remedied.

The rotor distributes the high tension current from the center of the distributor to the proper cylinder. Care must be taken to see that the distributor head is properly located, otherwise the rotor brush will not be in contact with the terminal at the time the spark occurs. The distributor head and rotor should be lubricated as described under the heading "Lubrication."

TOOLS AND TESTS

Too often the mechanic is handicapped by not having the proper tools to work with. No mechanic would attempt to overhaul an engine with the tools included in the car equipment, neither should he expect to make all of the practical tests on the electrical system without some additional equipment.

A voltmeter and an ammeter or a combination volt-ammeter is the one most important instrument that the mechanic can use in this work. The important points to remember when using these instruments are as follows:

No. 1. Do not test the storage battery with an ammeter as dry batteries are tested. (This will positively ruin the meter.)

No. 2. In taking an ammeter reading in the circuit where the approximate flow of current is not known; always use the highest scale on the meter and make the connection where it can be quickly disconnected in the event of a high reading.

No. 3. If the meter reads backwards, reverse the wires to the meter terminals. The meter will not be damaged by passing a current through it in the reverse direction as long as the amount of the current is not over the capacity of the meter.

No. 4. No damage will be done by connecting a voltmeter as an ammeter so long as the voltage of the system is not above the range of the voltmeter, but the ammeter should not be used as a voltmeter.

No. 5. A high-class instrument of this type will stand a momentary overload of from 200 to 400%. If the user is careful not to make his connections permanently until the current is normal, he will very seldom injure the instrument.

Next to the combination volt-ammeter the most important arrangement for the mechanic is a set of test points to use in connection with the electric light circuit. This is very easily made by tapping one wire of an ordinary extension lamp, splicing the wires on to which are attached suitable points with insulated handles in order that these may be handled with no

danger of electrical shock. With a set of test points as described the lamp will burn when the test points are together or when there is an electrical connection between the points. This will give more satisfactory results for testing for grounds, leaks, or open connections than will a bell or buzzer used with dry batteries, as the voltage is higher and it requires a small amount of current to operate the lamp. With a bell or buzzer a ground or open connection may exist, but the resistance is so high that enough current will not be forced through it by the dry batteries to operate the bell or buzzer.

No harm can be done to any part of the Delco apparatus by test points as described above when the ordinary carbon or tungsten lamp is used in testing purposes.

MOTORING GENERATOR

The motoring of the generator is one of the most important operations for the mechanic to familiarize himself with, as the same wiring and parts of the generator are used during this operation as when generating. Therefore if the apparatus will perform this operation properly, it is very sure to generate when driven by the engine.

An electric motor is caused to rotate by the magnetic attraction and repulsion between the iron core of the armature and the pole pieces which surround it.

During the motoring of the generator the pole pieces are magnetized by the current through the shunt field winding. The armature is magnetized by the current through the brushes and generator winding on the armature. It is necessary that current flow through both of these circuits before the armature will revolve. It is a familiar mistake to think that when current is passing only through the armature the armature should revolve. The ammeter on the combination switch can be depended upon to determine the amount of current flowing through the generator winding during this operation. Both the ignition current and the shunt field current flow through this meter, in addition to the current through the generator armature. The timing contacts should be open. This will cut off the ignition current and leave only the armature and shunt field current. Since the shunt field current is only 1¼ amperes, the reading of the ammeter will readily indicate whether or not current is flowing through the generator armature winding.

Should it be found that the current through both the armature and the shunt field winding is normal and the armature still does not revolve, the trouble may be caused by either (1) the armature being tight mechanically, due to either a sticking driving clutch, trouble in the bearings, or foreign particles jammed between the armature and pole pieces. This can be readily tested by removing the front end cover of the generator and turning the armature from the commutor end; (2) the shunt field winding or the generator armature winding may be defective in some manner, such as shorted, grounded, or connected to the motor winding. Any one of these would show an abnormal reading of the ammeter in some position of the armature when the armature is revolved by hand.

If the ammeter vibrates at each revolution of the armature during the motoring of the generator, and when the engine is running at low speeds, this is very conclusive proof that the armature has either a ground, open coil, shorted coil, or is connected to the motor winding.

TESTING ARMATURES

Complete tests to locate any armature trouble can be very readily made by the mechanic with no other equipment than the set of test points as formerly described. The indication of the different armature troubles and tests are as follows:

No. 1. Shortened Generator Coil. Charging rate low; meter vibrates when motoring the generator, or possibly the generator will only turn for a part of a revolution; meter vibrates when engine is running at low speeds; two or more adjacent commutator bars burn and blacken; cranking is slower than normal, but if only one coil is shorted this latter will not be noticed.

No. 2. Open Generator Coil. Charging rate is low; meter vibrates when motoring the generator, and when running at low speeds, the same as with the shorted generator coil;

severe sparking at the generator brushes when the engine is running, which causes serious burning at one commutator bar. This will not affect the cranking.

No. 3. Grounded Generator Coil. This will very seriously affect the cranking, causing it to be slow, and will soon discharge the battery with practically no charge from the generator; will cause burning of the commutator bars; is tested by insulating all brushes from the commutator and testing with the test points from the generator commutator to the frame of the machine. If grounded the test light will burn.

No. 4. Connected Motor and Generator Windings. The indications of this are practically the same as for a grounded generator coil, and is tested by insulating all brushes and testing with test points between the two commutators. The light will burn if the two windings are connected.

No. 5. Grounded Motor Winding. This will rapidly discharge the storage battery; is tested by insulating the motor brushes from the commutator, and test with the test points from the motor commutator to the frame. The light will burn if the winding is grounded.

The last three tests can be made with the armature removed from the frame.

IGNITION RESISTANCE UNIT

The ignition resistance unit is for the purpose of obtaining a more nearly uniform current through the primary winding of the ignition coil at the time the distributor contacts open. It consists of a number of turns of iron wire, the resistance of which is considerably more than the resistance of the primary winding of the ignition coil. If the ignition resistance unit was not in the circuit and the coil was so constructed to give the proper spark at high speeds, the primary current at low speeds would be several times its normal value, with serious results to the contacts. This is evident from the fact that the primary current is limited by the resistance of the coil and resistance unit by the impedence of the coil. (Impedence is the choking effect which opposes any alternating or pulsating current magnetizing the iron core.) The impedence increases as the speed of the pulsations increase. At low speeds the resistance of the unit increases, due to the slight increases of current heating the resistance wire.

CONDENSER

The condenser consists of two long strips of folded tinfoil insulated from each other by paraffined or oiled paper. The condenser has the property of being able to hold a certain quantity of electrical energy, and, like the storage battery, will discharge this energy if there is any circuit between its terminal. As the distributor contacts open the magnetism commences to die out of the iron core; this induces a voltage in both the primary and secondary windings of the coil. This induced voltage in the primary winding amounts to from 100 to 125 volts. This charges the condenser, which immediately discharges itself through the primary winding of the coil in the reverse direction from which the ignition current originally flows. This discharge of the condenser causes the iron of the coil to be quickly demagnetized and remagnetizes in the reverse direction, with the result that the change of magnetism within the secondary winding is very rapid, thus producing a high voltage in the secondary winding, which is necessary for ignition purposes.

In addition to rapidly demagnetizing the coil of the condenser prevents sparking at the breaker contacts—thus it is evident that the action of the condenser can very seriously affect the amount of the spark from the secondary winding and the amount of sparking obtained at the timer contacts. Therefore these are the means that are used for locating a defective condenser.

The action of the timer contacts can be observed by removing the distributor head and cranking the engine with the starter. A defective condenser will cause serious sparking. A slight spark will sometimes be observed with a good condenser.

The mechanic should familiarize himself with the spark obtained by removing the wire from one of the plugs and letting the spark jump to the engine (not to the spark plug). A good coil will produce a spark with a maximum jump of at least ½ inch, provided other conditions are normal.

IGNITION COIL AND TESTS

ne ignition coil is readily tested by the test points. The primary circuit is tested between the terminals on the top of the coil at the rear. The secondary winding can be tested for open circuit by testing the high tension terminal to either of the other terminals. The test lamp will not burn when making this test, on account of the high resistance of the secondary winding, but a spark can be obtained when the test point is removed from the terminal. No spark will be obtained if the winding is open.

A short in the secondary winding causes the spark obtained from a wire removed at the plug to be much weaker, and will cause missing when the engine is pulling, especially at low speeds.

CHECKING THE AMMETER

Should the charging rate appear to be abnormally low with no apparent reason, it is a good plan to check the ammeter by connecting another meter in series with it. Connect in the small line from the switch to the terminal on the generator.

These are very reliable meters, but automobile service is extremely hard service for a sensitive ammeter.

TO TIME THE IGNITION

No. 1. Fully retard the spark lever on the steering wheel.

No. 2. Turn engine to the dead center mark on the flywheel with No. 1 cylinder on the firing stroke.

No. 3. Loosen screw on center of timing mechanism and locate the proper lobe of the cam. Turn until rotor brush comes under the position which No. 1 high tension terminal on the distributor head occupies when the head is properly located.

No. 4. Set this lobe of the cam so that when the back lash of the distributor gears is rocked forward the contacts will be open, and when the back lash is rocked backward the contacts will just close. Tighten the screw and replace rotor and head. The shaft runs clockwise when viewed from the top, and the spark occurs when the contacts open.

GENERAL REMARKS ON THE CARE OF AN ELECTRIC SYSTEM

Do not fail to heed the battery instructions contained in Section 1.

By all means provide yourself with a hydrometer syringe.

The battery will require more care than all the other electrical appliances.

SECTION 6

AUTOMOBILE ELECTRIC STARTERS AND ELECTRIC SYSTEMS

Atwater-Kent, Bijur, Delco, Simms-Huff, Auto-Lite, Remy, Wagner, Ward Leonard, Dyneto, Bosch, Chalmers (Entz), Splitdorf-Apelco, Gray & Davis, and North-East Systems for Motor Cars.

Automobile Electric Starters and Electric Systems

THE ATWATER KENT SYSTEM OF IGNITION

This system of ignition is used on many makes of cars of high price, as well as those of a medium price. Regardless of the car it is used on, its operation is the same. Very little care need be given this system, and when it does require care the work of setting a part right is simple and is easily done by the average mechanic. Note the following instruction and cuts, which show the operation of the system, wiring, circuit diagram, and other interesting parts. By following this instruction the user should be in a position to care for a system, with the exception of extreme cases, where it will be necessary to take the car with this system to a repair shop. This is generally the case where open circuits occur in the system of wiring, or the wires that connect the parts together become grounded.

The Atwater Kent System consists of three parts:

1. **The Unisparker,** which combines the special form of contact maker, which is the basic principle of this system, and a high-tension distributor.

2. **The Coil,** which consists of a simple primary and secondary winding, with condenser—all imbedded in a special insulating compound. The coil has no vibrator or other moving parts.

3. **The Ignition Switch.**

The Atwater Kent System is manufactured in two forms: Type "K-2," with Automatic Spark Control, and Type "H," for use in connection with the regular spark lever. The electrical and mechanical features of the two systems are identical, except that in the Type "H" System the automatic spark control governor is omitted.

THE PRINCIPLE OF THE ATWATER KENT SYSTEM

The operation of the Unisparker is shown below. This consists of a notched shaft, one notch for each cylinder, which rotates at one-half the engine speed, a lifter or trigger, which is pulled forward by the rotation of the shaft, and a spring which pulls the lifter back to its original position. A hardened steel latch and a pair of contact points complete the device.

Figures 1, 2, 3, 4 show the operation of the contact maker very clearly. It will be noted that in Fig. 1 the lifter is being pulled forward by the notched shaft. When pulled forward as far as the shaft will carry it (Fig. 2), the lifter is suddenly pulled back by the recoil of the lifter spring. In returning it strikes against the latch, throwing this against the contact spring and closing the contact for a very brief instant—far too quickly for the eye to follow the movement (Fig. 3).

Fig. 4 shows the lifter ready to be pulled forward by the next notch.

Note that the circuit is closed only during the instant of the spark. No current can flow at any other time, not even if the switch is left "On" when the motor is running.

Note that no matter how slow or how fast the shaft is turning, the lifter spring will always pull the lifter back at exactly the same speed, and therefore the spark will always be the same, no matter how fast or how slow the engine is running.

The contact points are adjustable only for normal wear. All other parts of the contact

maker are of glass-hard steel, and are not subject to wear. They will outlast the motor, because they move but a very short distance, do very little work, and all friction has been reduced to a minimum.

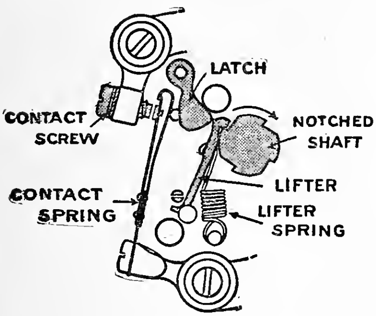


Fig. 1.
Contact Open.

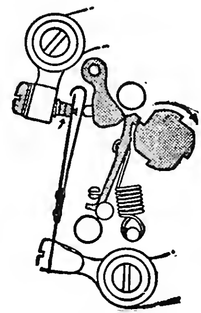


Fig. 3.
Contact Made.

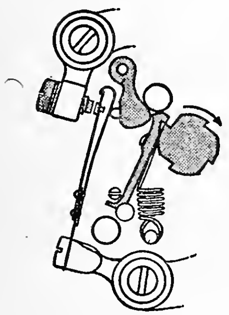


Fig. 2.
Contact Still Open.

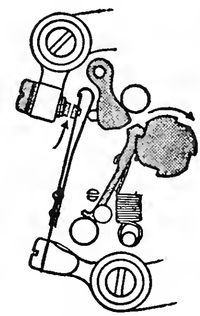


Fig. 4.
Contact Broken.

By means of the distributor, which forms the upper part of the Unisparker, the high-tension current from the coil is conveyed by the rotating distributor block, which seats on the end of the Unisparker, to each of the four spark plug terminals in the order of firing.

An important advantage which the Atwater Kent distributor possesses is the fact that there are no sliding contacts or carbon brushes, the distributor blade being so arranged that it passes close to the spark plug terminal without quite touching, thus permitting the spark to jump the slight gap, and eliminating all wear and trouble due to sliding contacts

DIRECTION OF ROTATION

The Type "K-2" Unisparker is manufactured only for clockwise rotation when looking down on the top of the distributor. In other words, the distributor block on the top of the shaft should rotate the same as the hands of a clock.

The Type "H" System, without the automatic spark control, is made for either rotation. It should be understood, however, that a given Type "H" Unisparker will not operate in both directions, but only in the direction for which it is specified.

Coil. Three coils are furnished with the Type "K-2" or "H" Atwater Kent System, a simple Plate Switch coil, the same coil with the addition of a more elaborate and heavier Kick Switch, and Underhood coil with separate switch. Both Plate and Kick Switches are provided with push-button for producing extra hot starting sparks.

UNISPARKER WITH MAGNETO MOUNTING

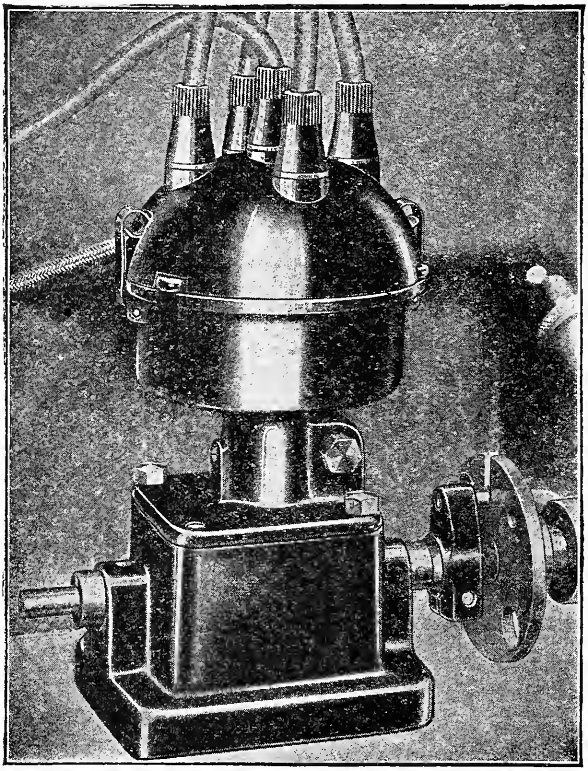


Fig. 5.

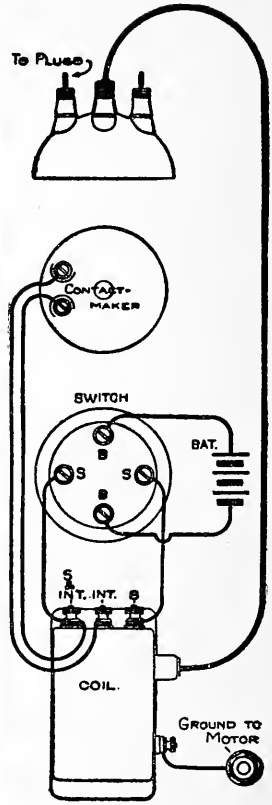


Fig. 6.

The Underhood Coil is the one commonly used by manufacturers as regular equipment. It is intended to be mounted in some convenient position under the hood of the car, and while it is built to stand the high temperatures incidental to this location, it should be placed in as cool a position as possible.

Switch. The Atwater Kent Reversing Switch is installed by cutting a hole 3 3-16 inches in diameter in the dash and setting in switch flush, fastening it with the three flat-headed screws furnished with the switch.

Wiring. The wiring of the Atwater Kent System is very simple, and is shown in the two diagrams, Figs. 6 and 7.

For the primary or battery circuits, use well insulated and braided primary wire, and see that it is protected against rubbing or abrasion wherever it comes in contact with metal. Where the lighting and starting battery is used for ignition, two wires from the ignition system should run directly to the battery terminals. They should not be connected in on any other circuit.

The contact maker of the Unisparker is connected to the coil by means of a length of twisted double conductor cord, which is furnished with the outfit. Do not under any conditions use separate wires for this connection.

The high tension wiring from the distributor to the coil and plugs should be the best possible grade of secondary wire 5-16 inch in diameter outside of insulation. The manner of making connections to the distributor terminals is shown in Fig. 8. It is recommended that

the connections between the spark plugs and the distributor be left until the Unisparker is "timed," so that the proper distributor points can be connected up in the correct order of firing.

In making these connections, the high-tension wire is bared for a space of about 1⅛ inches, and passed through the hole in the secondary terminal. The end of the wire is then

Fig. 7.

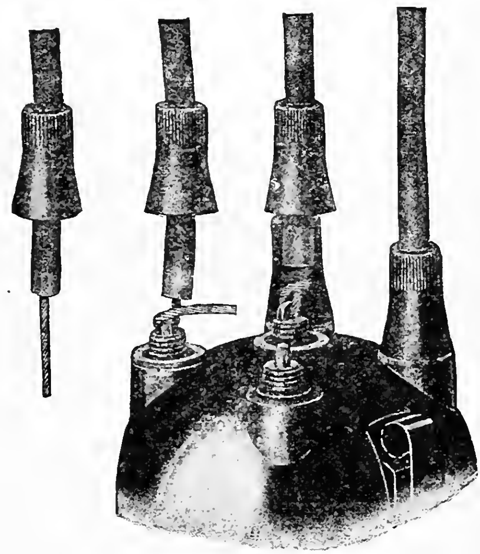


Fig. 8.

twisted back on itself for one turn, so that the end will not project beyond the diameter of the insulation. It will be found that when the terminal cover is screwed down the secondary wire will be tightly held. These terminals should be screwed down with the fingers—do not use pliers. The wires should never be soldered to the brass posts.

METHOD OF CONNECTING HIGH TENSION WIRES TO DISTRIBUTOR

Battery. If a special battery is used for ignition, this should consist of either a six-volt storage battery or six dry cells, connected six in series. If dry cells are used, see that they are insulated from each other and from the sides and bottom of the battery box by wood or fiber battens or partitions. The strawboard covers on dry cells have little, if any, insulating value when damp. See that cells are packed so that the connections cannot jar loose.

SETTING AND TIMING THE TYPE "K-2" UNISPARKER

(No Spark Control Lever Being Used.)

The Type "K-2" Unisparker should be installed so as to allow a small amount of angular movement for the initial timing adjustment. In other words, the socket with a clamp will permit the Unisparker to be turned and locked rigidly in any given position.

In timing the piston in No. 1 cylinder should be raised to high dead center, between compression and power strokes; then, with the clamp which holds the Unisparker loose, the Unisparker should be slowly and carefully turned backwards or counter clockwise (contrary) to the direction of rotation of the time shaft, until a click is heard. This click happens at the exact instant of the spark. At this point clamp the Unisparker tight, being careful not to change its position.

Now remove the distributor cap, which fits only in one position, and note the position of the distributor block on the end of the shaft. The terminal to which it points is connected to No. 1 cylinder. The other cylinders in their proper order of firing are connected to the other terminals in turn, keeping in mind the direction of rotation of the timer shaft.

When timed in this manner the spark occurs exactly on "center" when the engine is turned over slowly. At cranking speeds the governor automatically retards the spark for safe starting, and as the speed increases the spark is automatically advanced, thus requiring no attention on the part of the driver.

Note. If spark lever is used in conjunction with the Type "K-2" Unisparker, proceed the same as for Type "H," except that the spark control levers should be arranged so that the Unisparker moves not more than one-half inch from the full retard position to the full advance.

SETTING AND TIMING THE TYPE "H" UNISPARKER

The first operation in timing the Type "H" Unisparker is to crank the engine until the piston of No. 1 cylinder is on high dead center between the compression and power strokes.

The Unisparker is then placed on the shaft, the advance rod from the steering post being connected to the lug on the side of the Unisparker, which is provided for that purpose.

The position of the spark advance lever on the steering wheel sector should be within one-half inch of full retard, and the connecting levers should be such as to give the Unisparker a movement of at least 45 degrees to 60 degrees for the full range of spark advance.

After the spark lever is connected up and the Unisparker is in position, it should be left loose at the driving gear, and, with the motor on dead center as above directed, the shaft of the Unisparker should then be turned forward, or in the same direction as that in which the timer shaft normally rotates, until a click is heard, at which point it should be set by tightening the driving connection.

The Unisparker being properly set, the next thing to do is to get the secondary wires leading to the right plugs. To do this, remove the distributor cap, and note the terminal to which the distributor block points. This will be the proper terminal for No. 1 cylinder. The other terminals will then be wired up according to their firing order.

Adjustments. The only parts of the Atwater Kent System which are adjustable are the contact points. These are adjustable only for natural wear. (The initial adjustment made at the factory should be good for several thousand miles of service.)

Contact Point. The normal gap between the contact points is from .010 inch to .012 inch—never closer.

The contact points are made of purest tungsten, which is many times harder than platinum-iridium.

When contact points are working properly, small particles of tungsten will be carried from one point to the other, sometimes forming a roughness and a dark gray color on their surfaces. This roughness does not in any way affect the proper working of the points, owing to the fact that the rough surfaces fit into each other perfectly. However, when it becomes necessary to take up the distance between these points, due to natural wear, it is advisable to remove both contact screw and spring contact arm, and with a new fine file dress down the

high spots. This makes it possible to obtain a more accurate adjustment and eliminates any danger of high points on either contact touching each other when the system is at rest.

Please bear in mind that these contacts are very hard to file, and that it is necessary to remove only a very small amount of metal. Please also remember that although the contact surfaces may be very rough, they are probably in perfect working condition, the dark gray appearance being the natural color of the tungsten.

Oiling. The other parts of the contact maker—the latch, lifter, lifter-spring, and notched shaft—are not adjustable, and are not subject to wear if they are cleaned and oiled at intervals of six to seven weeks. (Note oiling diagram, Fig. 9.) Take care to avoid getting oil on the contact points.

Caution. Do not think that these parts do not work properly because you cannot see their movement, which is far too quick for the eye to follow. The contact maker of the Unisparker may be likened to a watch, which, because of the small size and extreme accuracy and hardness of its moving points, is subject to little or no wear, even after years of service. Both the latch and lifter are of glass-hard steel, and move only a short distance for each operation.

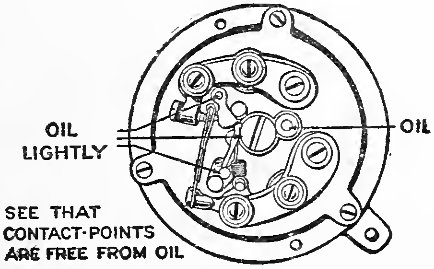


Fig. 9. Oiling Diagram.

Under no circumstances should they be altered in shape, nor should the tension or setting of the springs be changed. These are set right at the factory, and are the result of years of painstaking standardization.

IGNITION SYSTEM

Testing. If the engine misses without regard to speed, test each cylinder separately by short-circuiting the plug with a screw driver, allowing a spark to jump. If all cylinders produce a good, regular spark, the trouble is not with the ignition system.

If any one cylinder sparks regularly, this will indicate that the system is in working order so far as the Unisparker and coil are concerned, and the trouble is probably in the high-tension wiring between the distributor and plugs or in the plugs themselves. Examine carefully the plugs and wiring. Leaky secondary wiring is frequently the cause of missing and back-firing.

Frequently when high-tension wires are run from the distributor to the spark plugs through metal or fiber tubing, trouble is experienced with missing and back-firing, which is due to induction between various wires in the tube. This trouble is especially likely to happen if the main secondary wire from the coil to the center of the distributor runs through this tube with the spark plug wires.

Wherever possible, the distributor wires should be separated by at least ½″ of space, and should be supported by brackets or insulators, rather than run through a tube. In no case should the main distributor wire be run through a conduit with the other wires.

If irregular sparking is noted at all plugs, examine first the battery and connections therefrom. If the trouble commences suddenly, it is probably due to a loose connection in the wiring. If gradually, the batteries may be weakening or the contact points may require attention. See that contacts are clean and bright, and also that the moving parts are not gummed with oil nor rusted.

Note. Do not attempt under any condition to alter any of the parts of this system. Every part is exactly right in shape; every spring has the proper tension. Do not let the fact that the contact is made and broken so quickly that the movement cannot be followed by the eye cause any misapprehension. Do not alter or tamper with any of the parts.

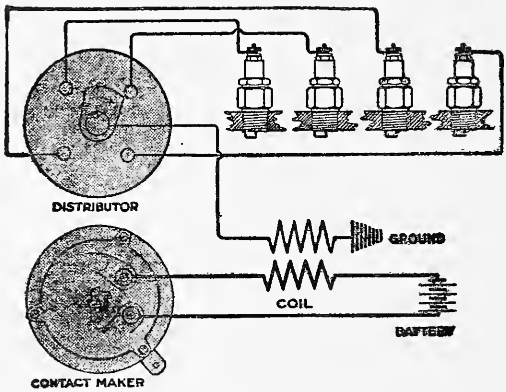


Fig. 10. Principle of the Atwater Kent Wiring Diagram.

In case of undue wear or breakage, return System complete to us for examination and repair, for which a nominal charge is made. When returning to us, advise by mail when and how shipment is made, also mark shipment so that it may be identified after wrapping is removed.

THE AUTO-LITE SYSTEM AS USED ON OVERLAND CARS

The Auto-lite System of starting and lighting is composed of three parts—the motor, generator, and storage battery. Besides these three parts, an ammeter, control switch, and circuit breaker are used. The motor is a simple series wound machine, and the current control is embodied within it. There are two windings around the pole pieces. One is called a shunt winding of a great many turns, and the other may be called a reverse series winding, which is of comparatively few turns. Current for exciting the fields flows through the shunt winding which is connected in shunt or across the armature. The current generated in the armature flows out to the system through the reverse series, which is connected in series with the armature. The current that flows through the reverse series winding flows around the pole pieces in the opposite direction to that of the current flowing through the shunt winding to excite the fields. The current flowing through the reverse series produces magnetism opposite to that produced by the current flowing through the shunt fields, and produces what is generally known as a bucking effect. As the speed of the generator increases the bucking effect increases. The generator begins delivering current to the system at a car speed of about 7½ miles per hour, and continues increasing in amperage until a speed of about 20 miles per hour is reached. At this time the generator has reached its maximum and is delivering to the system about 14 amperes. At speeds above 20 miles per hour the reverse series winding holds output down, and very little increase of current, if any, will occur. At about 15 miles per hour the generator is delivering about 10 amperes.

The circuit breaker is for the purpose of connecting or disconnecting the generator to the system. It is automatic and is controlled by the voltage of the generator. The control switch is located on the toe board, and is for the purpose of connecting the motor into the system of cranking. The Ammeter is connected in the charging circuit, and will show if current is flowing from or to the battery.

Care of the Generator. The silent chain which drives the generator should have frequent and thorough oiling. Ordinary lubricating oil will do for this purpose, and as soon as the oil has penetrated all of the joints, the surplus oil should be wiped off with a cloth.

This will prevent dust and dirt from adhering to the silent chain. The chain should be inspected occasionally to see that it has the proper adjustment. The chain must not be too tight, but enough slack so no strain is on the links when the engine is running. To tighten or loosen the chain, loosen the two screws that hold the generator to the bracket. The adjusting screws will be found on the side next to the engine. After the generator is in the proper place and its hold-down screws are tight, be sure to tighten up on the adjusting screw.

Should the battery be removed from the car, do not run car until it is replaced, unless a

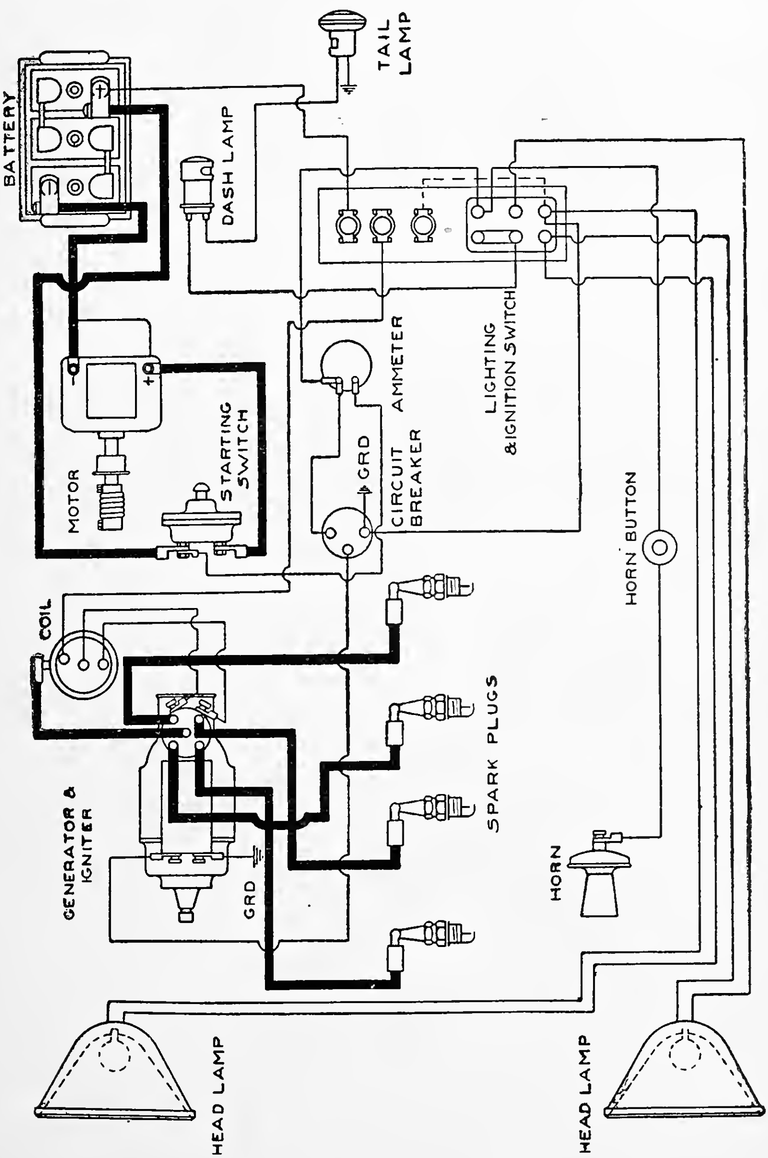


Fig. 11. Auto-Lite on Overland Cars.

piece of about No. 14 bare copper wire is connected from the generator terminal to the frame of the generator. This will prevent injury to the generator windings. Be sure to remove this wire when the storage battery is put back in the car. The storage battery is used rated at six volts and 80 ampere hours. The care of this battery is the same as that of any starting battery.

The wiring diagram for this system is shown in Fig. 11. Figures 12, 13, 14 show wiring diagrams of the Auto-lite System as applied to other pleasure cars.

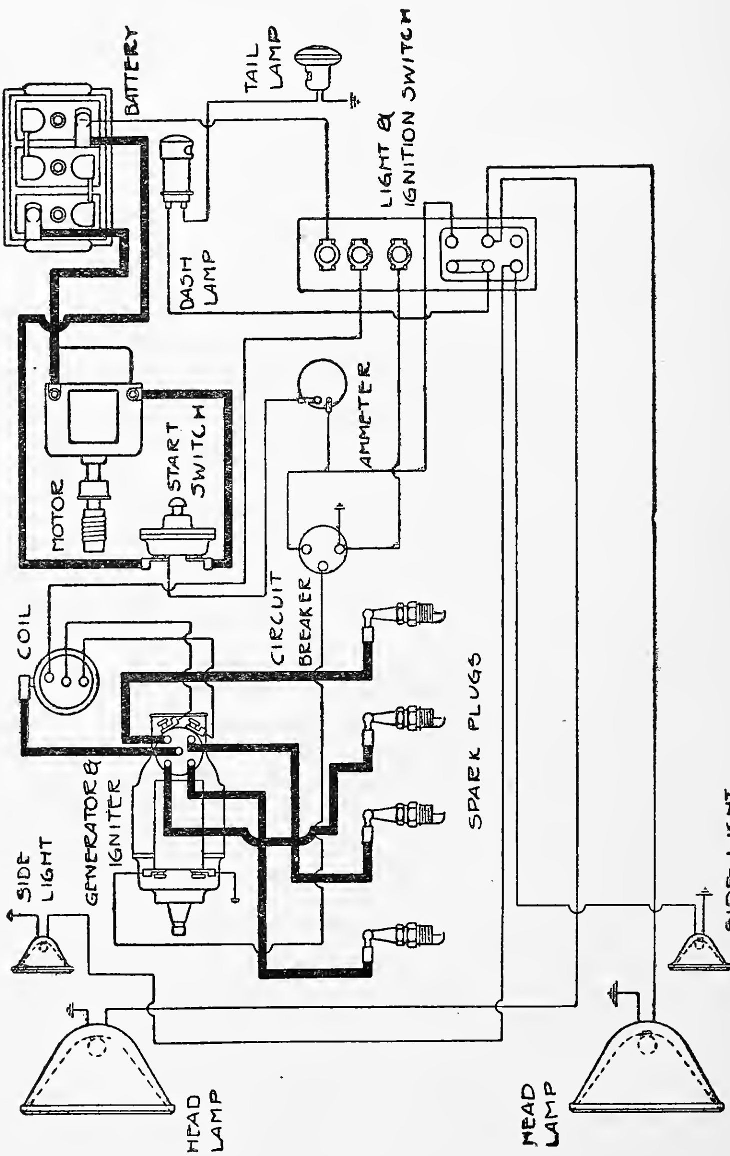


Fig. 12. Auto-Lite Standard Two-Unit Systems.

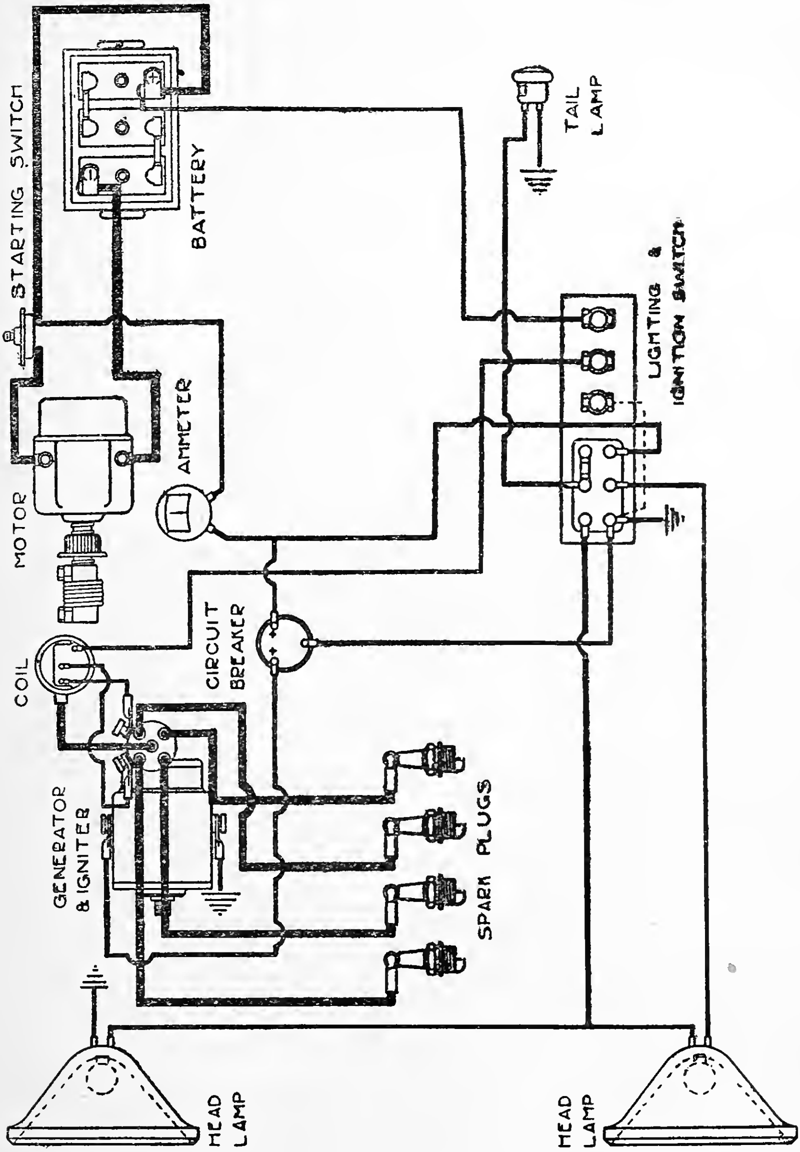


Fig. 13. Auto-Lite on Monroe Cars.

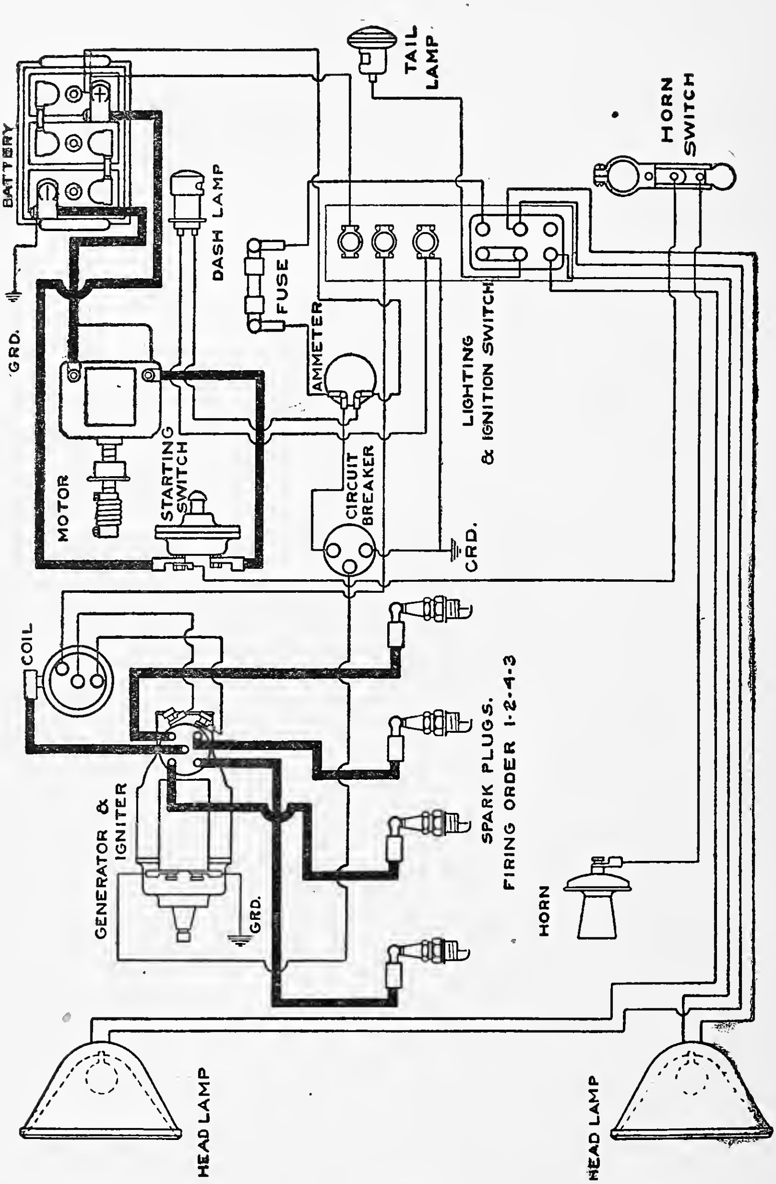


Fig. 14. Auto-Lite on Chevrolet.

BOSCH STARTING AND LIGHTING SYSTEMS

The Bosch Starting and Lighting System is composed of a motor, starting switch, generator, switch box (switch board), and storage battery.

The Starting Motor is of the series wound type, and is constructed to operate on either 6- or 12-volt battery. Copper gauze brushes are used.

The construction of the motor is such that the armature can be shifted endwise in its bearings, parallel to its axis. In the normal or non-operating position, the armature is held out of its electrical center, or, in other words, out of line with the pole shoes, by means of a spiral spring in the commutator end of the armature shaft; therefore when in the normal position, the pinion on the driving shaft of the starting motor is out of mesh with the gear ring on the flywheel of the engine.

The motor is regularly provided with three terminals, two of which are heavier or larger in diameter than the other. The two heavier terminals are for the main circuit, and the single small terminal is for the shunt circuit.

The Starting Switch is operated by means of a pedal, which, when depressed, causes current to flow from the battery to the motor for cranking the engine. The plate which carries the terminals of the switch also supports the metal band or strap termed the switch "shunt." The cable terminals are secured to the switch by means of a lock washer and nut.

When releasing the switch pedal the foot should be lifted entirely clear, so as not to retard the quick action of the spring. If for any reason the switch is operated too quickly, there will

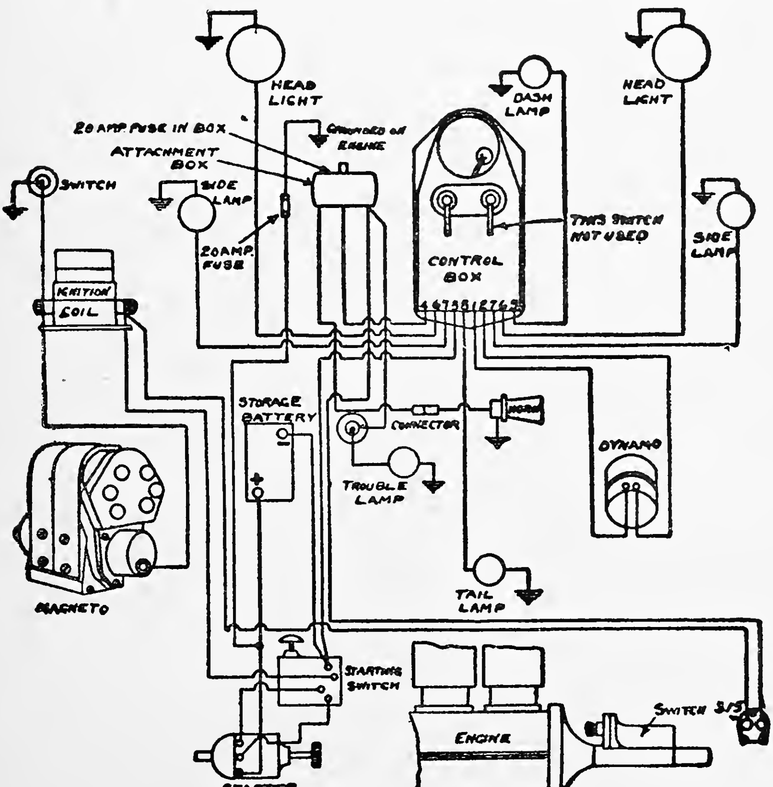


Fig. 16. Bosch Starter and Lighting Systems.

be no serious consequence, for the pinion on the motor shaft will not engage with the flywheel and the armature will rotate freely. It then becomes necessary to allow the pedal to resume its non-operating position so the starter can be operated.

The Generator is a simple shunt wound machine of water-proof construction, obtaining all regulations from external appliances. The regulator, which is located in the switch box, is so constructed that the voltage remains constant, irrespective of changes in speed or load, no matter how suddenly they may be made. The regulator is so constructed that it will maintain a fixed voltage while carrying the entire lamp load or at low speeds, and will not vary when a change is made either in speed or load. The generator carries the entire load, and the battery, should it be fully charged, simply "floats" on the line. This arrangement allows of the battery being used only when the engine is at rest. The battery may be disconnected from the system and no damage will result, as the regulator will prevent the voltage from rising to a pressure which will cause injury to the system.

The Switch Box contains the voltage regulating devices as well as the control switches, which are used for the purpose of cutting the generator circuit in or out. The meter for giving condition indications is also incorporated in the switch box, as are the switches necessary for controlling the different generator and battery combinations as well as lighting combinations. On the underside provisions are made for making the individual circuit connections. It is possible by means of the switch levers to run with or without the battery, with or without the generator, and have any lights burning the driver may wish; any position of the switch can be retained by the combination locking arrangement. Figure 16 shows the system as applied to the Marmon car.

BIJUR SYSTEM FOR STARTING AND LIGHTING

This system consists of a motor, starting switch, and a generator. The motor is in operation only when the starting operation is taking place. The generator supplies current to the system at car speeds of about 10 miles per hour or over. An automatic switch at the generator closes the circuit between the generator and the storage battery when the voltage of the generator is high enough to charge the battery and opens the circuit between the generator and the battery when the voltage of the generator falls below that of the battery. The output of the generator will vary all the way from 4 to 25 amperes, this all depending upon the state of charge in the battery. If the state of charge is low the charging rate may reach from 15 to 25 amperes, and when the battery is in a changed condition the charging rate may drop as low as 4 or 5 amperes. Do not attempt to regulate the charging rate upon finding the charging rate low. First test the battery, and if the battery is found to be charged, that is the reason for the charging rate being low. When making connections at the generator or in the generator wire to the storage battery, no attention need be paid to polarity. Simply connect one wire to each terminal. If the wires are put on in a reversed order from where they were when taken off, the polarity of the generator will reverse and the generator will charge the battery. Fig. 17 shows a general wiring diagram of the system where ammeter is used. The instruction as given us by the manufacturer of this sytsem in regard to care, maintenance, oiling, and how to locate and remedy troubles is as follows:

DIRECTIONS FOR CARE AND MAINTENANCE

Regularly every month the disconnecting plug should be pushed inwardly to unlock it, and turned past its vertical position until it springs back and locks.

This turning of the disconnecting plug in its socket should not be done after the car has been standing for a prolonged period with lights in use. It should be done when the battery is in a charged condition.

The disconnecting plug is the brass plug containing the generator wires, and which fits into the extended brass receptacle on the end of the regulator box on top of the generator. This plug has two flat parallel faces.

The plug should never rest in its receptacle so that these flat faces stand in a vertical

position, as in this position the generator is disconnected, but should be pushed in and turned in either direction past its central position until it locks.

To remove the regulator box from the generator disconnecting plug should be pushed inwardly and turned to its central position. When in this position the plug may be withdrawn from its socket. After removing the plug, the knurled screw head on top of the box should be loosened and the box lifted from the generator by grasping the plug receptacle and the box at the same time. Do not hammer the receptacle in order to release the box.

OILING

Regularly every two weeks, or every five hundred miles, two or three drops of thin neutral oil should be put in each of the two oilers of the motor and in each of the two oilers of the generator. Do not flood the bearings with oil.

Regularly every two weeks, or every five hundred miles, the square shaft of the starting motor should be oiled with about ten drops of cylinder oil.

Note. In cold weather only light oils should be used for the gas motor, as heavy oils become stiff and make cranking difficult.

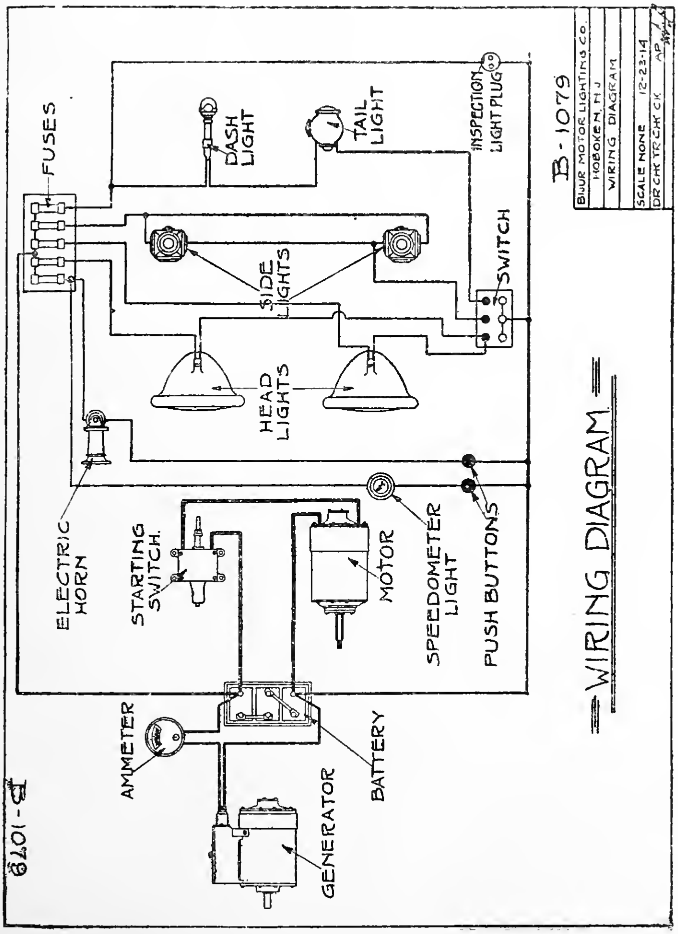


Fig. 17. Bijur System.

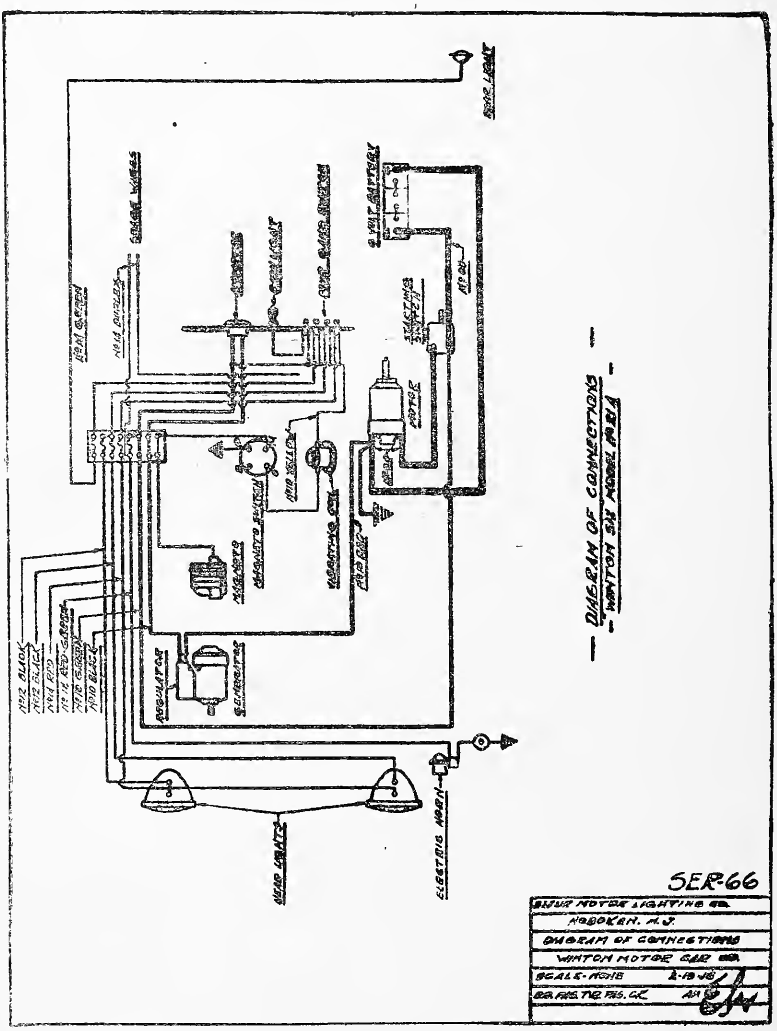


Fig. 18. Bijur System.

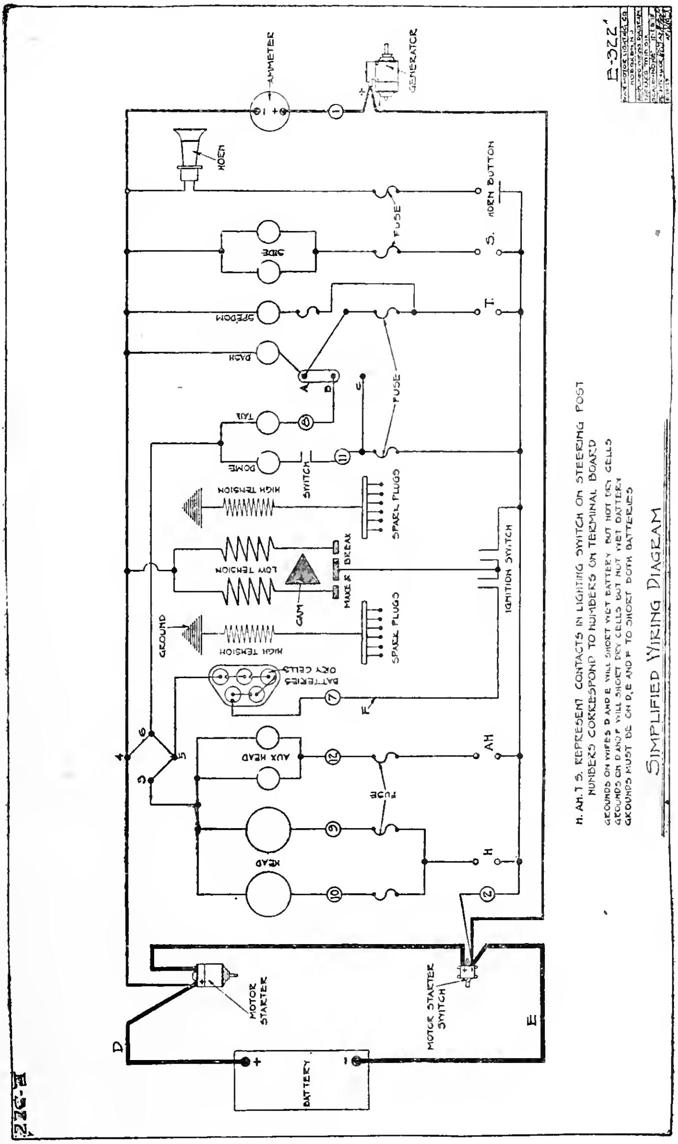


Fig. 19. Bijur System on Packard Cars. (Simplified Circuit.)

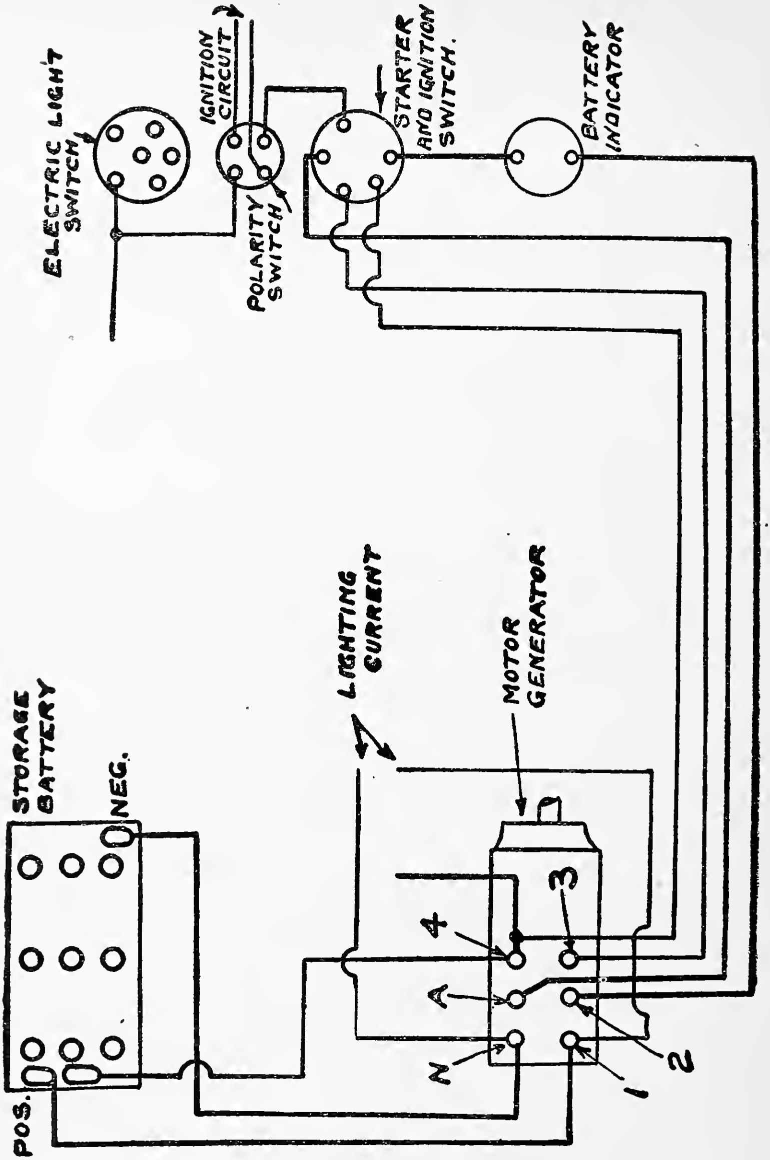


Fig. 20. Chalmers (Entz) System.

THE CHALMERS (ENTZ) ELECTRIC STARTING SYSTEM

The parts of this system are as follows: Motor-generator, starting switch, and 18-volt storage battery. The starting switch controls both starting and ignition. The motor-generator has two windings in the field coils and one winding on the armature. When operating the motor-generator as a motor the series and shunt fields work together and make it a compound wound machine, thereby increasing the cranking power. When operating as a generator the field windings operate differentially, the series winding acting as a reverse series and controlling the output of the machine. There are no automatic cut-outs used, as the switch

for starting and ignition is also the means of opening and closing the circuits between the generator and storage battery. Turning the starting switch on the "ON" position closes the ignition circuit and at the same time connects the motor to the storage battery and the engine is cranked. When the engine is running from its own power at a speed equivalent to 7 or 8 miles per hour the motor-generator is automatically converted into a generator and charges the battery. For all ordinary driving the starting switch should be left in the "ON" position. If the engine is running below speeds of 7 or 8 miles per hour the switch should be in the neutral position. This prevents the waste of current, as the motor-generator will act as a motor at these speeds. At all times when the speed of the engine is above 8 miles per hour, be sure that the switch is in the "ON" position. Fig. 20 shows the system as applied to the Chalmers Light Six, which is better known as Model 26-B. If at any time the starting system should fail or the generator does not supply current to the system, follow the instruction as given with other systems in regard to keeping the commutator clean, brushes making good contact, wires loose or terminals corroded. The lamps used in connection with this system are 21-volt. As a dimmer these lamps are connected in series, and for ordinary driving they are connected in parallel. This is done by the operation of the lighting switch. Atwater Kent ignition is used. For information on the ignition system, see instruction on the Atwater Kent System.

THE DYNETO SYSTEM

This system consists of three main parts: Motor-generator, starting switch, and storage battery. The motor-generator is wound for 12 volts and combines in one machine means for starting, lighting, and battery charging. No automatic cut-out or regulator is used. As a generator it will begin charging the battery at 1,100 revolutions per minute of the generator. Charge at 5-ampere rate at 1,400 R. P. M., and 10 amperes at 1,700 R. P. M. Note that this is a 12-volt system, and the charging rate need be but half of that of a 6-volt system. In this system there is but one machine with but one armature, one set of ball bearings, one set of brushes, and very simple wiring. The motor-generator is of very high efficiency, which is permanently connected with the engine by means of a silent chain with a reduction of 2½ to 3 to 1. The three units are connected together by very simple wiring, consisting of two wires from motor-generator to the switch, one wire to the battery, and one wire through the switch to the battery.

In starting the switch is to be closed and left so. The motor-generator will then operate as a motor and spin the engine at from 125 to 200 R. P. M., depending upon the engine to which it is connected. After the engine begins to run under its own power the motor-generator will automatically change to a generator and charge the battery. At speeds of about 10 miles per hour the motor-generator operates as a generator, and at speeds below 10 miles per hour it operates as a motor. The power available as a motor increases as the engine speed decreases, and at very low speeds prevents the engine from stalling. The regulation of the generator is accomplished by the differential action of the shunt and series field windings, the maximum current being fixed to suit the capacity of the battery used. The armature coils are form wound, and are so designed that no two wires cross each other, thus preventing the development of short circuits. The main frame is made of pressed steel and has six pole pieces bolted to it. The field coils are all form wound, the shunt and series coils being separately taped and insulated before placing in the machine.

Starting switch has three positions—off, start, and neutral. The switch may be locked in the off position so that the car cannot be started, even by hand, as ignition is also controlled by it. The neutral position is for long drives with a fully charged battery. In this case, while the armature will run just the same, it will not generate. The position start is for starting. This position is also for running when lights are being used or the battery is charged. The starting switch replaces the usual ignition switch, as ignition is also controlled by it. A 12-volt, 60-ampere hour battery is generally used. The lamp bulbs for head lights should be 14 volts, side lights 14 volts, and speedometer and tail lights when in series 7 volts. Be sure that the speedometer and tail lights are of the same voltage and candle power on all systems where they are in series with each other. No fuses are used in the main circuits of the system, but

are generally used in the lighting and ignition circuits. See Fig. 26, which gives a simple circuit and wiring diagram combined.

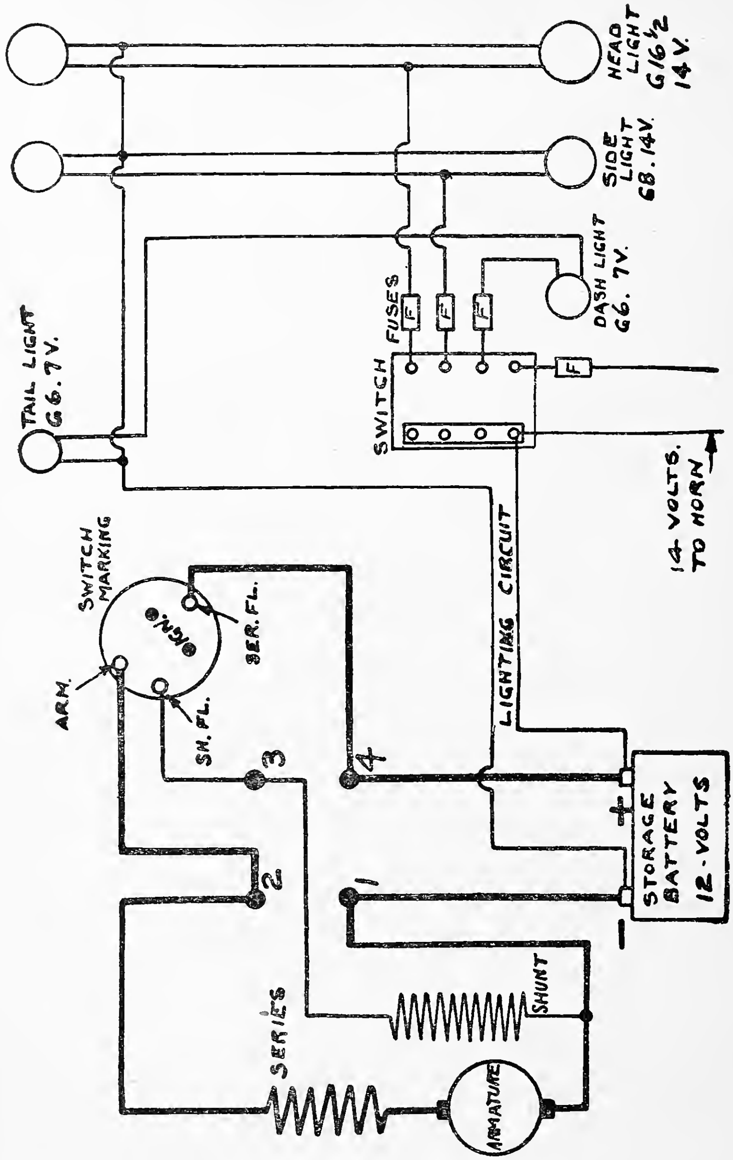


Fig. 26. Dyneto System.

TROUBLES, AND HOW TO OVERCOME THEM

If starter will not start (crank engine), do not leave switch on start position. Turn on lamps. If they burn bright, watch them and try starting again with the lamps on. If they do not drop in candle power it is quite likely that there is an open circuit in the starting wires, starting switch, terminals, or brush connection to the commutator. Be sure that the brushes are not worn out, are free in the brush holders, and that the springs are in a condition to press

them firmly against the commutator. If, with switch on start, lamps drop slightly in candle power and motor fails to crank the engine, the trouble may be due to loose connections, rough or dirty commutator, brushes worn out, or not fitted to the commutator, weak brush springs, grounded or defective armature or field windings and weak battery. If lamps burn very dim when switch is turned to start, look at the battery, as it may be discharged or nearly so, loose or corroded connections at the battery or other wires in the circuits may be loose. If starter cranks engine but very slowly, look for high resistance in cranking circuit due to wires being too small, loose terminals, bad soldered joints, poor switch contacts, rough commutator, short brushes without sufficient spring tension, and weak battery. The cause for the battery being weak may be due to grounds, unnecessary use of the lights, or from cranking the engine too long at a time when it fails to start due to poor ignition or gasoline. Also the carburetor may be out of adjustment.

If the generator fails to generate, the trouble will probably be found in an open shunt field circuit. See Fig. 26. This circuit may be traced as follows: From negative pole of battery to terminal No. 1 through shunt field in generator to terminal No. 3, then to terminal on starting switch marked Sh Fl, through switch to terminal marked Ser Fl, then to terminal No. 4, and to positive of battery. This circuit may be tested out independently of the main circuits by removing wire from terminal No. 2 so as to cut out the armature circuit, being sure that the switch is on start. If the circuit through shunt field is all right a bright spark will occur when wire is removed from terminal No. 3. If no spark occurs, look over all wires and connections and an open circuit will be found. To test shunt field alone, remove all wires from the generator and test from terminal No. 1 to terminal No. 3. If generator does not generate enough current, connect ammeter in charging circuit. To connect ammeter remove wire at terminal No. 1. Attach one side of ammeter to terminal No. 1, and the wire taken off of this terminal to the other side of the ammeter. This will give the rate the battery is being charged. Be sure that all lights are turned off.

Examine battery and connections. Be sure that there are no loose connections in the circuits; go over the shunt circuit through generator; note that the commutator is clean and smooth and that the springs keep the brushes pressed firmly against the commutator. Grounds and short circuits often occur in wires not being protected, their insulations being cut or oil-soaked. These grounds and short circuits are often found in lamps, lamp sockets, and their connections. See Fig. 26 for complete wiring diagram.

GRAY AND DAVIS SYSTEMS (TWO-UNIT SYSTEM)

The Generator has two principal parts: The field, in which magnetism is induced, is stationary. The armature, in which electrical current is generated, rotates within the field. The generator has the characteristics of a compound wound machine; that is, the field strength, or magnetism, automatically increases as additional work or load is applied, or vice versa. But it is of the shunt wound type and is thus classed, because its shunt field windings are connected in shunt with, or across, the armature. Reference to Fig. 27 shows the shunt field windings in parallel; one side connected to the positive brush; the other passes through the regulator points and is connected to the negative generator brush.

The Regulator Cut-Out performs two duties: One to regulate the generator for uniform output. The other to connect the generator into the system only when sufficient current is generated, and when generator slows down, when current is insufficient to charge the battery, to disconnect generator from the system to prevent battery from discharging back through the generator. The shunt winding, series winding, cut-out points, regulator points, and field resistance are shown in Fig. 27. The shunt winding is permanently connected across the generator armature. It causes the cut-out armature to be attracted, closing the cut-out points. The series winding when the cut-out points are closed, assists the shunt winding in holding the cut-out points firmly together. The cut-out points, when closed, connect the generator into the system. The regulator points, when closed, short circuit or shunt the field resistance, and when drawn apart, insert the field resistance into the field circuit. The field resistance retards the flow of current into the fields. When generator is at rest the cut-out points are

open and the regulator points closed. As generator first speeds up, the regulator points remain closed. Thus, the field resistance is short-circuited, permitting the generator to build up under full field strength. When the proper voltage is reached, the cut-out points close, permitting current to flow through the series winding to the system. As the generator speed increases beyond that necessary for full output, the pull of the shunt winding attracts the regulator armatures. This reduces the pressure at the regulator points and inserts a resistance into the field circuits which prevents further increase of output. The varying of the pressure at the points which allows the resistance to be put into the circuit is intermittent. The frequency is in proportion to the speed variation. When lamps are turned on the frequency at the regulator points is reduced and the generator output is increased, giving the generator compound wound characteristics. The regulator cut-out terminals are marked B, L, A, F, and Fi. B is negative (—). B is the end of the regulator cut-out series and connects to the battery through the indicator. L is also negative (—). L is connected to series at a given distance from the end and connects to the lamps through the lighting switch. The positive brush holder of the generator connects to, or "grounds" to the frame of the generator. Therefore generator frame is positive (+). Connections between regular cut-out and generator are as follows: A connects to generator negative brush. F connects to one field coil, and Fi connects to the other field coil. The generator must be driven as designated by letters C. C. W. D. E. (counter clockwise driving end), or C. W. D. E. (clockwise driving end). The generator must be kept clean and the bearings lubricated regularly. Lubricate generator once every two weeks or every five hundred miles. Be sure that the oilers are not stopped up. Do not assume that oil has reached the bearings, but be certain. Overflow of lubricant at oiling places does not always indicate that bearings have been properly lubricated. Type "T" generator is rated at 6½ volts, 10 amperes, 1000 R. P. M. Type "S" generator is rated at 6½ volts, 10 amperes, 650 R. P. M. This means that the generator will deliver a current of 10 amperes and 6½ volts pressure when armatures are rotated at 1000 or 650 revolutions per minute, respectively.

The generator output will vary slightly with battery condition. When battery gravity is low the output will be higher. When battery gravity is high the output will be lower. At speeds of 10 to 12 miles per hour, with lights off, battery receives full charging rate, but as lights are turned on, current flows to the lamps, and charging rate is reduced. Owing to the compound wound characteristics of the generator, it permits the battery to receive a low charge when all lights are on.

Generator Fails to Generate. This is shown by the indicator, which will not indicate "Charge" when the engine is running at high speed, but indicates discharge when lights are turned on. To prove if the indications of the generator are reliable, turn all lights on; then, when the engine is running at a speed equivalent to 10 miles per hour, disconnect wire at terminal "B" on regular cut-out. If lights go out it proves that generator or regulator cut-out is at fault. Reconnect wire at terminal "B," then remove side plates from generator to examine brushes. Slide the brushes in and out and be sure that they slide freely in the brush holders, make good contact with the commutator, and that the wires from brush holders and fields to generator terminals are firmly connected. The commutator, if coated or dirty, should be cleaned by using kerosene and a piece of cheesecloth. Use kerosene sparingly, and be sure to wipe dry. If micas are high they should be grooved out below the surface of the metal. See that the screw between terminals "L" and "B" on regulator is securely fastened. If, after following the foregoing instructions, the trouble has not been corrected, connect a wire at regulator cut-out from terminal "A" to terminal "B" when engine is speeded up above 10 miles per hour and all lights are turned off. If indicator then indicates charge, the regulator cut-out is at fault. But if the indicator slows neither charge nor discharge, the brushes are not making good contact to the commutator or there is an open in the generator circuit at some point. If indicator indicates discharge, reduce the engine speed to 8 or 9 miles per hour. Then connect another wire from "F" and "Fi" to terminal "A." If indicator then indicates charge, the regulator is at fault; but if indicator still indicates discharge, it shows that the generator field circuit is open or armature is short-circuited.

THE STARTING MOTOR

The starting motor has two principal parts: The field, which is stationary, and the armature, which revolves within the field. The starting motor cranks the engine until it runs from its own power. It is the link between the battery and the engine. Electrically the starting motor is connected to the battery through heavy cables and the starting switch. Mechanically it is connected to the engine through a gear reduction having a sliding flywheel engaging pinion and an over-running clutch. The sliding engaging pinion and starting switch are operated by the same operation of the starting pedal, so that electrical and mechanical connections and disconnections occur at the same time. When starting pedal is pressed to the full limit the electrical energy stored in the battery is transmitted to the motor, causing the armature to rotate. This mechanical energy is transmitted to the engine through the gears and over-running clutch, causing the engine to rotate.

Pressing the starting pedal to the full limit of its travel moves the sliding pinion forward and also closes the starting switch. If the sliding pinion is in a meshing position it slides into mesh with the fly-wheel gear. If the pinion teeth, instead of sliding between, should strike the ends of the flywheel teeth, the switch and rod complete their travel, which compresses the shifter fork spring and closes the switch. When the pinion begins to turn, the compressed spring throws the sliding pinion into full mesh with the flywheel gear and permits starter to crank the engine. When the engine picks up and runs from its own power the roll clutch prevents the engine from driving the starting motor, as the gears are in mesh until starting pedal is released. The purpose of the over-running clutch is to prevent the engine, when cranked by the starting motor, to pick up without driving the starting motor, which is temporarily connected to the engine when starting pedal is pressed. When the engine runs faster than when revolved by the starting motor, the rolls in the over-running clutch are released from wedge-shaped angles, permitting over-running action of clutch, thus preventing any dragging effect on the motor.

Lubricate starting motor regularly every two weeks with good oil.

At all oiling places apply eight or ten drops each time and return oiler covers to their closed positions. Sliding surfaces and rods must be oiled frequently. The gear case should receive one tablespoonful of heavy motor oil every three months and return oil plug to oil hole. If starting motor cranks the engine when starting pedal is pressed to the full limit of its stroke and engine does not start (run from its own power) after 10 or 15 seconds, release the pedal and determine reason for failure. Any of the following may be the cause: Fuel supply exhausted or turned off; ignition switch not turned on; ignition wires not firmly connected; spark plugs dirty or defective; cylinders need priming; cylinders flooded from too much priming; carburetor out of adjustment, or the fuel supply may be of poor grade.

If pressing the starting pedal to the full limit of its stroke fails to rotate the motor and crank the engine, release the pedal at once. The battery may be weak or discharged, battery cables may not be in firm contact with the battery, starting switch or motor; starting switch not making good contact, engine may be very stiff or stuck in bearings, or motor brushes may not be making good contact with the commutator.

If starting motor rotates and the engine fails to spin, any of the following may be the cause: If same is accompanied by little noise the trouble is likely in roller clutch, which does not grip properly. Sliding surface of shaft may be dry or injured, preventing flywheel pinion from sliding easily into mesh with the flywheel gear. If accompanied by much noise, the trouble is most likely with sliding pinion, which fails to mesh with the flywheel. In this case a heavier shifter spring should be used.

Lighting Switch. The fused lighting or junction switch serves the purpose of a common center for lighting, ignition, and horn circuits. It controls head, side, and rear lamps from one base and centralizes all fuses and connections in an accessible position. When dimmer bulbs are used in head lights instead of side lights, these wires are connected to the side-light connections on the switch. The fuses mounted on rear of lighting switch are in the lighting, ignition, and horn circuits. Always use fuses of same carrying capacity as taken out or replaced.

Obtaining Service When Battery or Generator Is Out of Service. When emergencies require temporary corrections of the trouble, proceed as follows: If battery is defective and is to be removed, disconnect the two wires to each battery terminal and wrap the ends with insulating tape. All lamps should be turned on to prevent excessive voltage at the lamps. Generator will furnish sufficient current to the lamps when the engine is running above ten miles per hour. If the generator is at fault and must be removed from the car, disconnect wires from terminals B and L on regulator and connect these two wire ends firmly together, being sure to wrap with friction tape. This will complete the battery circuit to the lamps. If the battery should be found discharged and the generator is out of service, it should be charged from an outside source at once.

The Indicator. The indicator is a current indicating device. It tells if the system is working right. It indicates charge when current is flowing to the battery, and discharge when current is flowing from the battery. When it indicates neutral no current is flowing to or from the battery. If it indicates discharge when lights are not turned on with engine standing still, it indicates that there is a ground or short circuit in the system. If it indicates neutral when generator should be charging the battery, it shows that the charging circuit is open or the generator is at fault. The indicator is not free from error. The pointer may become bent as a result of short circuits. To prove if in error, disconnect wires from indicator terminals or disconnect wires from negative terminal at the battery. The difference between neutral (zero) and where pointer stopped is the variation to be allowed whenever taking the indicator readings. If indicator does not indicate discharge when the lights are turned on and the engine is at rest, the indicator is at fault. If indicator shows discharge when generator should be charging the battery, and shows charge when the engine is at rest with lights turned on, the wires to the indicator terminals are reversed. If indicator hand swings intermittently from charge to neutral when engine is running above 10 miles per hour, any of the following may be the cause: Screw on regulator cut-out between terminals B and L not making good connection from regulator to ground; loose wire in the charging circuit; poor contact through brushes to the commutator; high micas in commutator or loose wires at battery. An ammeter is used on certain makes of cars instead of the indicator. Its charge and discharge scale is graduated. Otherwise it is similar to the indicator and performs the same function. If a car is equipped with an ammeter instead of an indicator, substitute the word ammeter for indicator where the latter appears in these pages.

The units of this system should be connected with wire or cable of the following sizes: Generator wires to battery and lighting switch should be No. 10 B & S gauge. Wires from lighting switch to head lights, No. 12 B & S gauge. Cable from battery to starting motor and starting switch, No. 1 B & S gauge. All other wires, No. 14 B & S gauge. In replacing defective wires never use wires smaller than given above. Wires or terminals when fastened under a screw or nut must be provided with a lock washer to prevent loosening, due to vibration. Use a plain brass washer between lock washer and terminal wire. In order that wiring troubles may be quickly corrected, it is important to have a general knowledge of a system, which can be gained by studying the wiring diagrams. Figs. 27 and 28 are very similar to each other, the only difference being in the starting motor circuit. On some cars the system is grounded at the motor and on others at the starting switch. The system on the Peerless, Chandler, Stearns, Winton, Metz, Velie, Crow, Imperial, Jones, Elkhart, Partin, Palmer, Enger, and Meteor is grounded at motor. On Chalmers, Paige, and Maxwell the system is grounded at the starting switch.

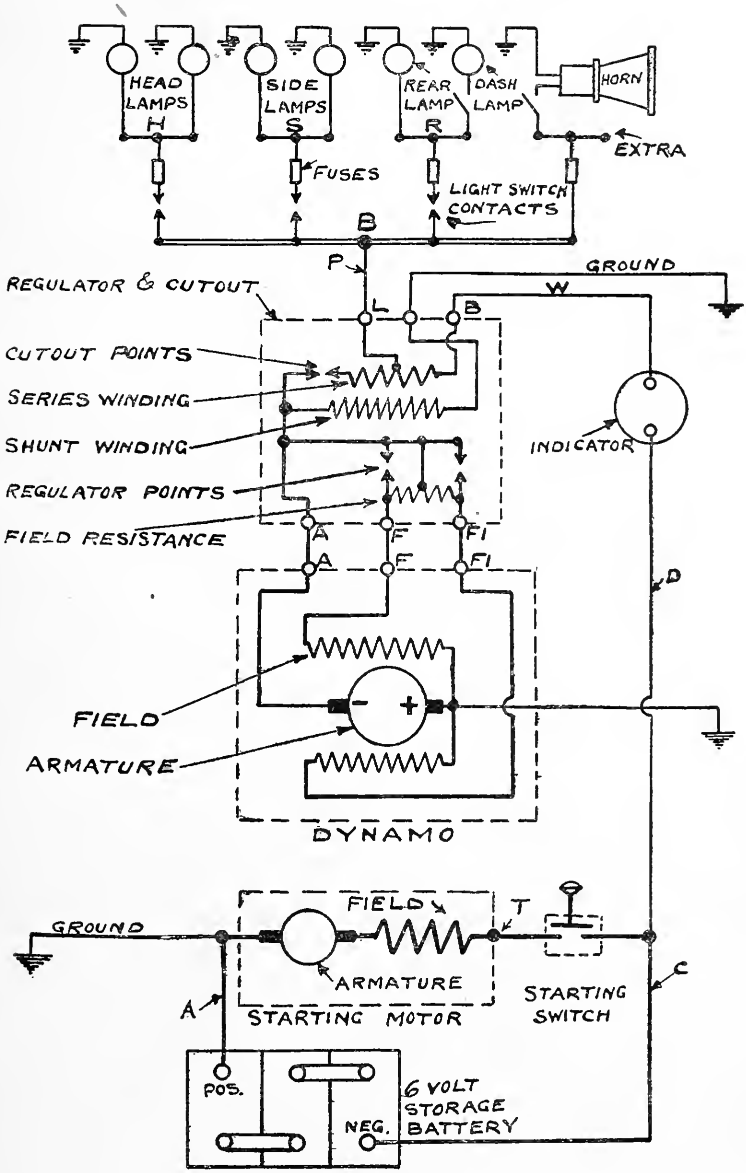


Fig. 27. Gray & Davis Two-Unit System (Grounded Motor).

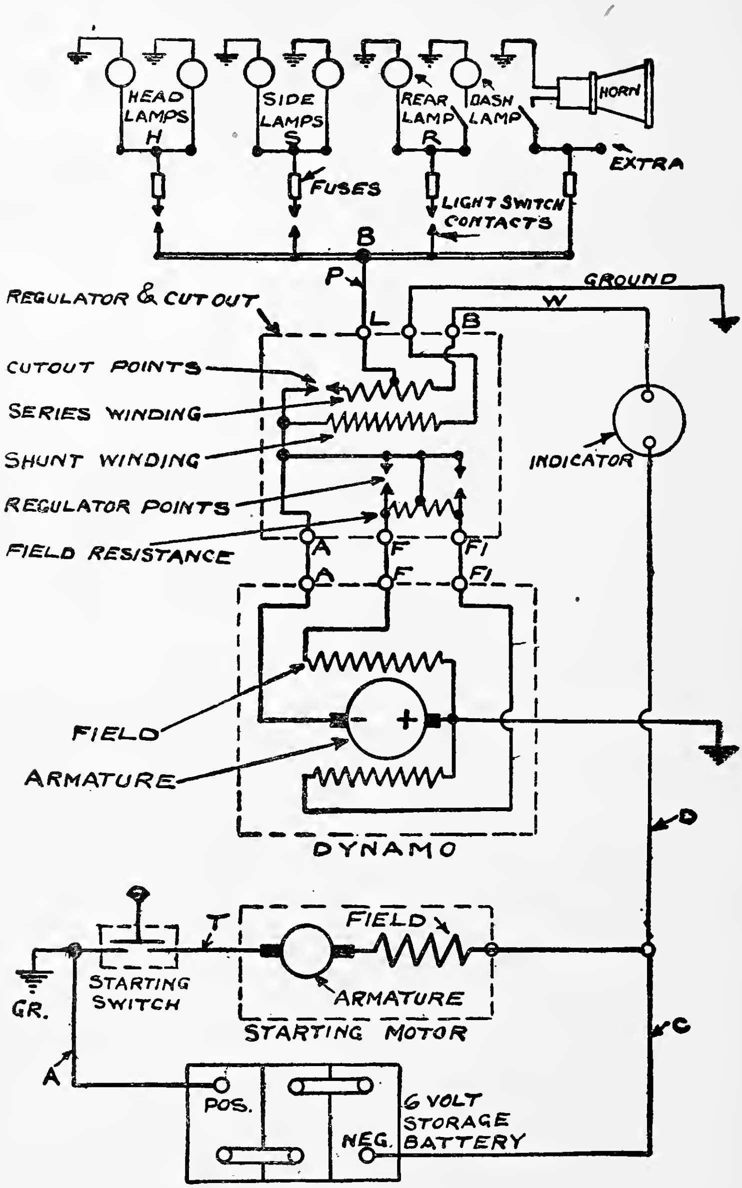


Fig. 28. Gray & Davis Two-Unit System (Grounded Switch).

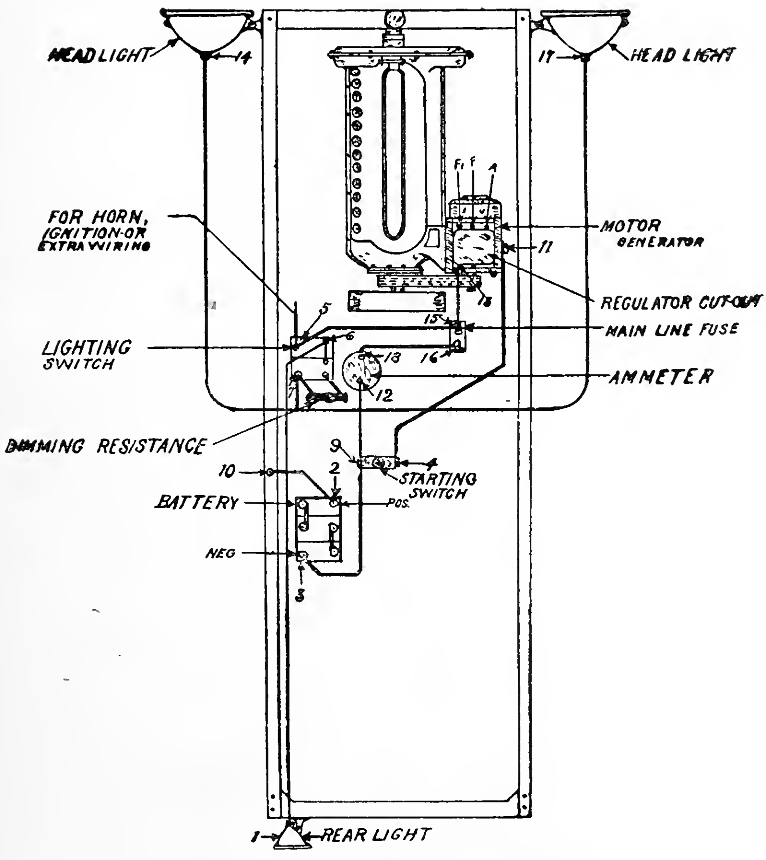


Fig. 29. Gray & Davis Single Unit System.

THE NORTH-EAST SYSTEM

The single unit North-East Starter-Generator is connected by a silent chain drive. The complete system consists of this starter-generator, the starter switch, the 12-volt storage battery and current indicator. The starter-generator is connected at all times to the engine by means of a sprocket keyed on the front end of the crank shaft, another sprocket on the armature shaft of the starter-generator, and a silent chain running over both of them. The ratio of armature shaft to crank shaft revolutions is 3 to 1.

The negative terminal of the storage battery is connected direct to the starter-generator and the positive terminal of the battery is connected to the current indicator, and from this indicator to the starter-generator. The two lower wires on the starter-generator connect it directly with the switch.

STARTING

After the ignition switch has been turned on, pressing down the starter switch pedal will crank the engine. This operation closes the circuit between the battery and the starter-generator and causes the latter to act as a motor, turning over the crank shaft of the engine by means of the silent chain drive. As soon as the engine begins to run under its own power the starter switch should be released, thus breaking the circuit between the battery and the starter-generator.

REGULATION

After the car has attained a speed of 10 to 12 miles an hour an automatic cut-out, built integral with the starter-generator, closes the generating circuit between the starter-generator and the battery, thus allowing a charging current to be conducted from the starter-generator to the battery. When the car speed falls below 10 to 12 miles an hour, this automatic cut-out opens the generating circuit and thus prevents the battery from discharging through the starter-generator, except when the starter switch is pressed down for starting the engine. To prevent overcharging the battery the windings of the shunt and series fields are differentially compounded when charging, and in addition there is built integral with the starter a regulating device which inserts sufficient resistance into the shunt field winding so as to prevent the generator current from ever exceeding a certain fixed rate at which the battery can be charged indefinitely without danger of overcharging, regardless of what speed the car may attain.

The starter-generator is of the 12-volt single unit type, one armature and one set of field windings, acting both as a motor and a generator. Both the cut-out and regulating devices are contained in the sealed compartment directly beneath the brush compartment.

If for any reason the battery be disconnected from the circuit, the starter-generator should not be run by the engine unless the small fuse, which is located directly above the brushes, is removed. Otherwise, this fuse will burn out and open up the shunt field winding automatically, thus protecting this winding from the excessive internal current generated by the starter-generator when the battery is disconnected. As soon as the battery is replaced the fuse should be reinserted in its clips, as otherwise no current will be generated to charge the battery. The burning out of this fuse can be detected when the car is running at a speed of 10 to 12 miles an hour or greater by the failure of the current indicator to show "Charge," providing, of course, that all of the wiring connections are tight and there are no short circuits or grounds. Even if this fuse has been burnt out the engine can still be started, providing that the battery has not been discharged too much, as the series field circuit, which does most of the work when the starter-generator is used as a motor, has not been broken.

STORAGE BATTERY

The battery is of the 6-cell, 12-volt type. It is located under the driver's seat, at the left side. Besides the two wires leading from it to the starting system, a ground wire is connected to the frame to complete the single wire or grounded lighting system; the battery thus furnishing current both for lighting and starting the car.

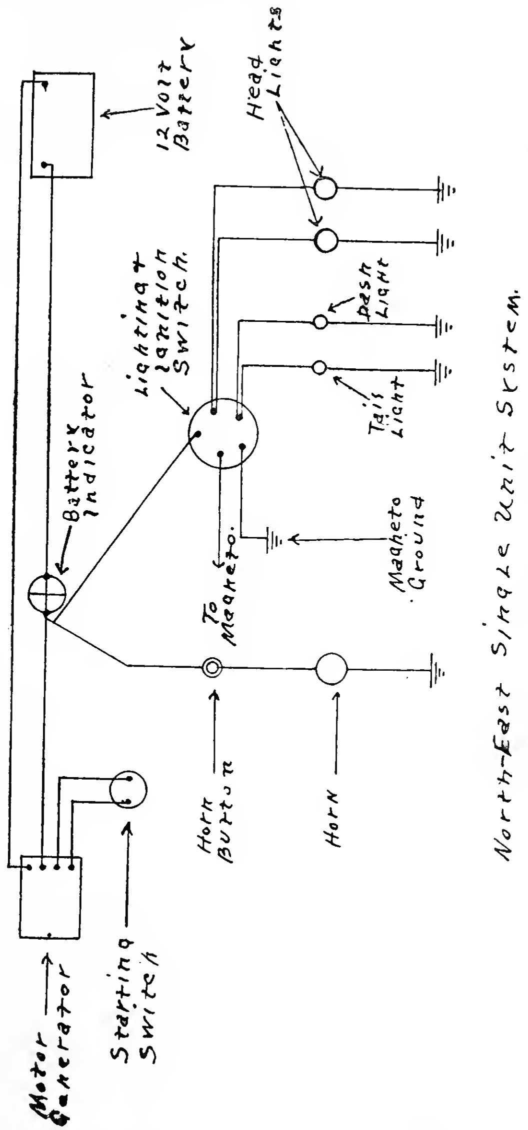


Fig. 31. North-East System.

There are two head lights, a dash light, and a tail light. The lamp sizes are.

Head lights	15 candle power—14 volts
Tail light	2 candle power—16 volts
Dash light	2 candle power—16 volts

Both headlights are connected to one terminal of the lighting switch by separate wires, so that if one wire should be short-circuited the other light would still burn. The tail light and dash light have separate wires leading to another terminal at the back of the switch. The lighting switch has three positions, "Off," "Dim," and "On." In the "Dim" position the tail light, dash light, and head lights connected to the dimmer are turned on. In the "On" position the tail light, dash light, and head lights bright are turned on. All of the lights are connected in parallel so that the burning out of any one of them will not affect the others.

At the back of the ignition and lighting switch are five terminal connections. Starting at the top of the switch and moving in a clockwise direction, the terminals are for the following wires: Magneto to switch wire, current indicator to switch wire, tail light wire and dash light wire, two head light wires, and the switch ground wire. To the back of this switch is connected a dimmer resistance coil through which the current flows when the lighting switch handle is turned to the "Dim" position.

CURRENT INDICATOR

The current indicator is located on the left side of the instrument board and is inserted along the line of the wire leading to the starter-generator from the positive terminal of the battery. To one of the current indicator terminals are connected the wires which conduct the current to the lighting switch and the horn. This indicator not only registers the charge and discharge of the battery, due to starter-generator action, but also registers discharge when the battery is supplying current for the lamps; when the generator is supplying current to the battery, the indicator will show "Charge" even when all the lamps are burning. "Discharge" will appear on the indicator when the starter-generator is used for cranking the engine, or when the lights are being used while the engine is not running above a speed corresponding to a car speed of 10 or 12 miles per hour. If at any time the current indicator fails to register properly, inspect its terminal posts and see that the wires leading to it are tightly attached. Also see that there is no short circuit in the wiring system. The indication of "Discharge" when "Charge" should be indicated is almost a sure sign that there is a short circuit in the wiring system, unless the wires connected to this current indicator have been connected up in reverse direction to the actual current flow. If no short circuit can be found in the wiring, remove the current indicator and inspect it for an internal short circuit.

ELECTRIC HORN AND BUTTON

The electric vibrator horn is located under the hood and attached to the cowl dash. Current is conducted to it by a wire attached to one of the binding posts of the current indicator, leading through the horn button on the left front door to the horn. A single wire is employed and the horn is grounded. The horn button is of the all-way type and can be operated by the driver's left knee.

REMY STARTING-LIGHTING-IGNITION

Two Units Six-Volt System

IGNITION-GENERATOR

The Ignition-Generator is a low speed, six-volt Generator of the four pole, shunt wound type. It starts charging the battery at a very low speed and its output is sufficient to keep the battery fully charged under starting, lighting, and ignition loads. The control of this output is automatically obtained by means of a regulator with vibrating contacts which intermittently throws a high resistance in series with the generator field.

A special copper-carbon composition is used for the brushes and these are mounted upon arms pivoted to the rocker ring. The position of the rocker ring should never be changed, as this is determined upon and the ring accurately set at the factory.

The ignition distributor, which embodies both the distributor and the circuit breaker, is simple in design and is readily accessible for inspection at any time. In addition to its simplicity, the strength and durability of the unit are emphasized by the very small number of moving parts, the large size bearing for the rotating shaft, the constant lubrication of this bearing by an oiler, the extra large contact points, and the grade of material used.

The distributor is of the most reliable form, the high tension current being distributed to the spark plug cables by a segment which revolves close to but does not touch the pins in the distributor head.

This ignition distributor and coil produce a spark which is of practically constant intensity, regardless of engine speed, which gives ideal low-speed operation, the very best of

engine acceleration, and which reduces the necessity of carburetor adjustment to a minimum. Furthermore, as the spark is synchronous throughout the entire range of speed of the engine and as the sparks delivered to each cylinder are equal in intensity, it tends to develop at all speeds the maximum horsepower of which the engine is capable.

RELAY-REGULATOR

It is necessary to have some device to connect the generator to the battery while the engine is running, and to disconnect the battery when the engine comes to rest. If this connection is not made when the engine is running, the generator output will rise to a high value and the generator protective fuse, located on the relay-regulator base, will be burnt out, thereby rendering the generator inoperative.

If the generator is not disconnected from the battery when the engine comes to rest, the battery will discharge itself through the generator windings. A simple electrical switch which is mounted beside the regulator on a bakelite base automatically performs this operation. It is known as "relay" and consists of an arm mounted upon pivots and iridium-platinum contact points.

When the engine and consequently the generator is at rest or running at a speed below that necessary to generate voltage equal to the battery voltage, a spring holds the contact points apart. As soon, however, as the voltage of the generator reaches the value of the battery voltage, the current flowing through the shunt coil of the electro-magnet energizes this magnet to such an extent that it pulls the arm down, thus bringing the contact points together and connecting the generator to the battery.

Up to this point all current used is supplied by the battery. When the relay points close the generator starts delivering current into the line and supplies part of the current used for lighting and ignition. As the engine speed rises, the output of the generator builds up very quickly, so that at very low speed the generator supplies all of the current used for lighting and ignition. At any higher speed than this, the current delivered by the generator is in excess of that necessary for lighting and ignition, and this excess is stored in the battery.

The relay contact points are held together as long as the voltage of the generator is in excess of the battery voltage, but as soon as the generator voltage drops below that of the battery the spring forces the contact points apart, thus disconnecting the generator from the battery.

Two different regulators are employed, one having but one set of contact points and the other having two sets, one set being mounted upon springs. Their operation, however, is the same, the output of the generator being controlled in the same manner in each case.

The correct maximum output for the generator is determined by the tension of the spring under the regulator arm adjusted so that when the generator is running at a speed lower than that necessary to generate this maximum output, the spring holds the contact points together. The current supplied to the generator field passes directly through these points. As soon, however, as the speed of the generator tends to cause its output to rise above this predetermined maximum, the current flowing through the coil on the electro-magnet energizes this magnet to such an extent that it pulls the arm down. This pulls the contact points apart, forcing the field current, which heretofore had been passing through them, to pass through the resistance unit. This resistance decreases the field current, which in turn decreases the output of the generator. Further, as the entire output of the generator passes through the coil on the regulator electro-magnet, the energizing effect of this electro-magnet coil is reduced, so that the spring forces the contact points together again, thereby cutting the resistance out of the field circuit. With a normal field again, the generator output immediately starts to build up and the operation just described is repeated. A continuous repetition of this operation sends a pulsating current to the generator field and holds the output at a practically constant value.

For the purpose of protecting the generator, a readily accessible fuse is fitted to the relay regulator base. If the battery should become disconnected, either through accident or neglect, this fuse will burn out, rendering the generator inoperative and damage proof.

IGNITION COIL

The coil supplied with this system has been designed and so developed and proportioned that an exceptionally efficient spark is produced at all speeds. It possesses the further distinct advantage of operating satisfactorily on as low as $2\frac{1}{2}$ volts should the voltage of the battery ever fall that low due to leakage of current, indiscriminate use of starting motor, or lights, or to other causes. The metal base of the coil makes an electrical connection with the bracket upon which the coil is mounted for one side of the secondary or high tension winding and the condenser. It is very important, therefore, that the coil be fastened down securely to this bracket at all times.

STARTING MOTOR

The starting motor is a four pole, series wound motor and is very sturdy and compact in construction. While developing ample power to spin the engine at a high rate of speed, it has been so developed that the current consumed has been reduced to a minimum commensurate with the power required.

The commutator and brushes of this motor are designed to carry very heavy current without injury.

The position of the rocker ring upon which the brushes are mounted should never be changed, as this is determined upon and the ring accurately set at the factory.

INSTRUCTIONS FOR OPERATION AND MAINTENANCE OF IGNITION-GENERATOR

In order to procure the best results from any mechanical device it is important that it be properly installed and that it be operated and cared for with consideration. This ignition-generator is sturdy in construction and efficient electrically, yet it is essential that it be properly cared for in order that perfect results may be obtained.

An oiler is provided for oiling the bearings on each end of the ignition-generator. Oiling should be in proportion to conditions of usage, care being taken not to flood the generator with oil. Under normal conditions the bearings should be given 5 or 6 drops of oil every 1,000 miles. **Do not oil the commutator.**

The grease cup directly underneath the distributor head should be kept full of a medium cup grease. The cap should be screwed down 2 or 3 turns occasionally in order to force the grease into the distributor shaft bearing. In case the cup should be supplied with a wick use pure vaseline instead of cup grease.

COMMUTATOR AND BRUSHES

As a matter of precaution, we advise that an inspection of the commutator and brushes be made occasionally. Under average running conditions an inspection should be made about twice during a season. This may easily be accomplished by removing the band around the commutator end head.

The surface of the commutator should be clean and bright. If it appears rough and blackened the armature should be rotated slowly and the surface smoothed down with a piece of fine (00) sand paper (preferably worn or used paper). **Never use emery cloth for this purpose.** After cleaning commutator carefully remove all sediment from between the commutator bars and from the generator body. The brushes should make perfect contact with the commutator and should swing freely upon their pivots.

The brushes are of a copper-carbon composition and under average condition will last indefinitely. If replacement should be necessary from any cause, do not use carbon substitutes, but obtain the special brushes furnished by the Remy Factory, Branch Houses, Service Stations, or Parts Stations.

IGNITION

The circuit-breaker points should be inspected occasionally by removing the distributor head. They should make good contact at all times and should have a smooth, clean surface.

If found to be rough or worn unevenly, they should be smoothed up with a very fine file, or preferably by drawing between them a piece of fine (00) sandpaper.

The contact screw should be adjusted so that the maximum opening of the points is .020 or .025 inches, or the thickness of the piece riveted upon the side of the small wrench furnished with the system. The rebound spring should be at least .020 of an inch from the breaker arm when the points are at the maximum opening.

We recommend the use of spark plugs which permit of their points being adjusted to a definite gap. To obtain the best results the gap between these points should be from .025 to .030 of an inch. If the motor misses when running idle or pulling light, the spark plug gaps should be made wider. If the motor misses at high speed or when pulling heavy at low speed, the gaps should be made closer.

It should be borne in mind that there are many things which will cause the motor to miss and act like ignition trouble, viz.: carburetor being out of adjustment, leaky valves, incorrect valve timing, air leaks in intake manifold or around valve stems, motor not oiling properly, lack of compression, etc.

BULBS

In the event of bulb replacement use single point Mazda bulbs only. Use seven-volt bulbs of the same candlepower unless the dash and tail lights are connected in series, in which case use 3½-volt bulbs.

INSTRUCTIONS FOR STARTING MOTOR

The starting motor is intended to perform one function only, viz., spin the engine, and should only be used for such purpose. Any attempt to propel the car by the starting motor or indulge in needless use of same are experiments of no material value and are no test of the starting motor, but simply impose an extravagant demand upon the battery.

The closing of the starting switch completes the circuit and puts the starting motor in operation. If it does not spin the engine, release the switch at once, ascertain if all connections are tight and secure, and inspect the battery. If the starting motor turns the engine over very slowly it is evident that the battery is weak or the engine exceptionally stiff.

If the starting motor is spinning the engine at a reasonable cranking speed and the engine does not fire, remember that the starting motor is performing its duty, so do not let it continue to spin the engine longer than necessary, as a needless drain is placed upon the battery. If the engine does not fire, it is evident that the trouble is confined to carburetor or ignition.

Oilers are provided for oiling the bearings on each end of the motor. These should be given 4 or 5 drops of good oil once every 1,000 miles.

As a matter of precaution, an occasional inspection should be made of the commutator and brushes to see that the brushes are not sticking in the holders and to see that the commutator is clean and bright. Carefully clean off all dirt from the commutator and brushes.

SHORT CIRCUITS AND GROUNDS

If the insulation is worn off any one of the wires and the copper touches any of the metal parts of the car, that wire is said to be "grounded." As the metal parts of the car are used for one half of the electrical circuits, this forms a complete circuit, joining two opposite sides of the generator, and is called a "short circuit" inasmuch as there is no apparatus in the circuit to utilize the current. A short circuit of this kind dissipates current from the generator and battery and will either cause a fuse to burn out or will, in time, completely discharge the battery. If the wires are not insulated again, there is danger also that the output of the generator will rise to a value that will burn out the generator protective fuse.

IGNITION FAILS

A break in the ignition circuit is the first thing to look for when trouble of this kind is experienced. See that there are no open or short circuits, then follow out the instructions given carefully.

Examine the high tension leads, see that they are all fastened securely to the distributor head and to the spark plugs, and that they are not grounded to the engine at any point. Examine particularly the lead connected to the middle terminal on the distributor head; see that it is making good connection to the terminal on the side of the coil.

ALL LIGHTS GO DIM

A short circuit in the wiring or a defective battery might be the direct cause of this trouble.

The indirect cause is a discharged battery due to short circuits in the wiring, leaving

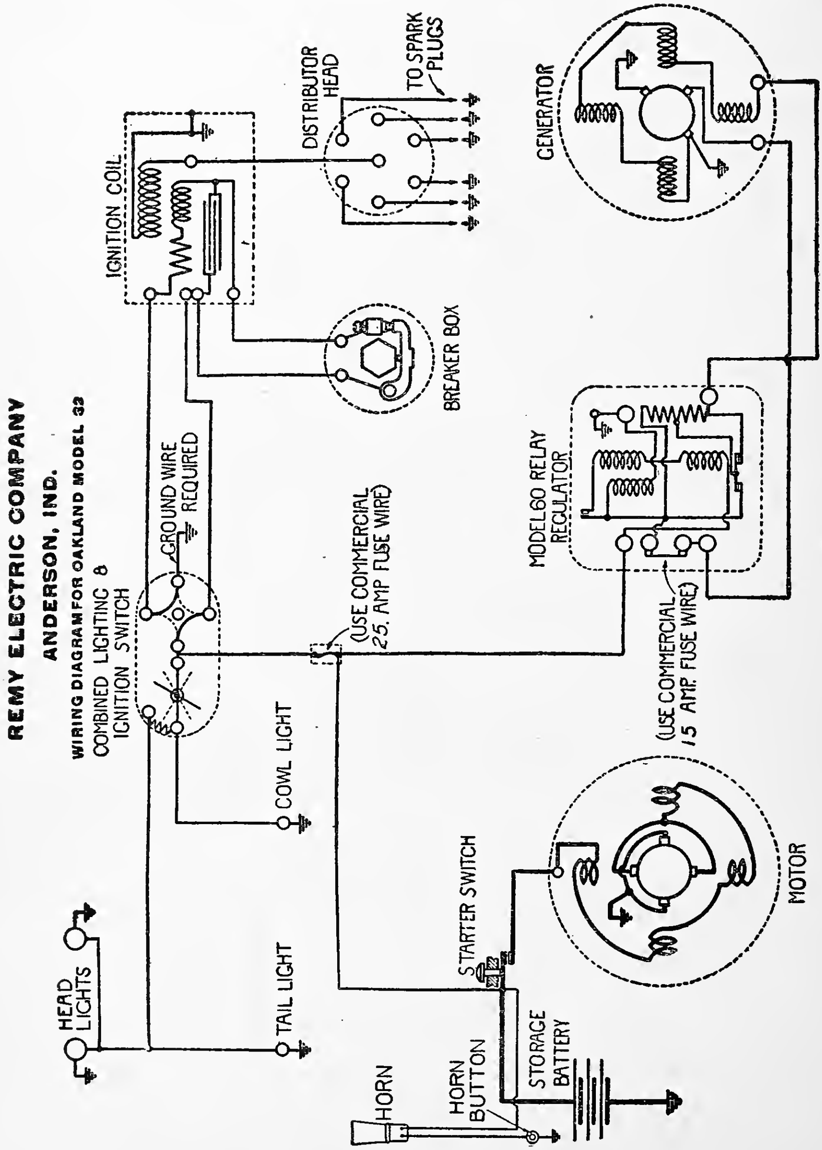


Fig. 32.

the ignition switch turned on when the engine is not running, using bulbs or greater candle power than those recommended, indiscriminate use of the lights or starting motor, using low efficiency carbon filament bulbs, or generator not charging properly.

If the ammeter registers discharge with all lights and the ignition off and the engine idle, it would indicate that there is current from the battery being dissipated in a short circuit in the wiring or that the ammeter is out of order.

To test this, disconnect the cable from one of the battery terminals. If the ammeter hands return to zero, it is proof that there is a short circuit in the wiring which is dissipating current from the battery.

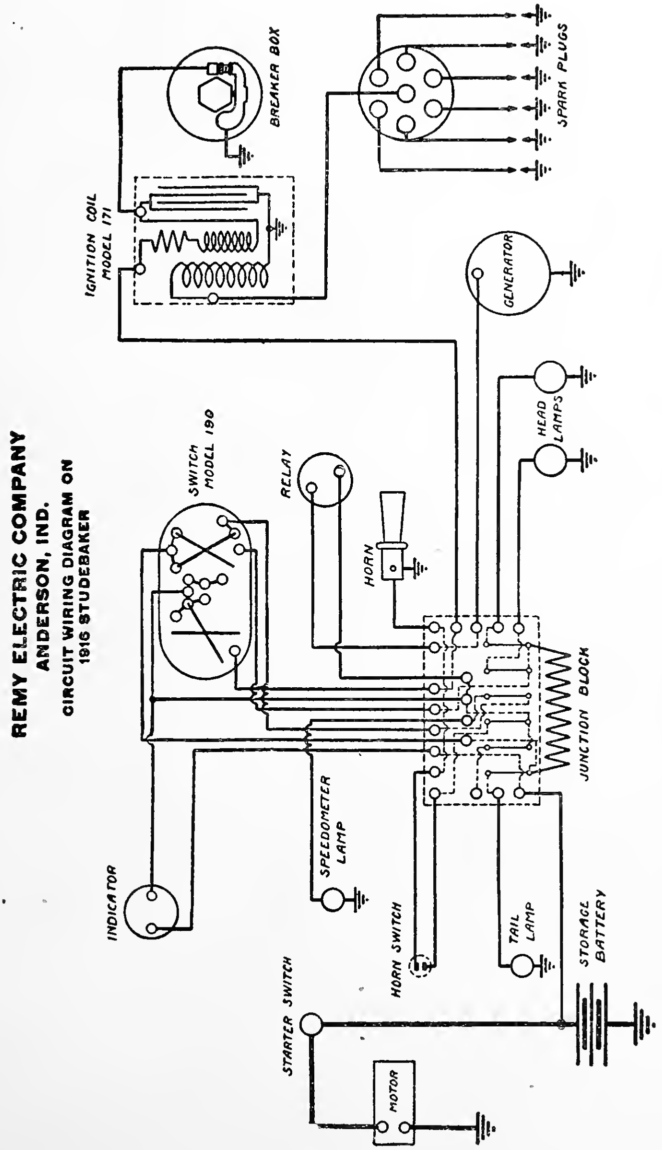


Fig. 33.

If the ammeter does not register charge with all lights off and the engine running, it would indicate that the generator was not charging properly. An inspection should be made of both relay and regulator contact points and all dust and dirt carefully removed. A small quantity of dirt lodged between these points will keep the generator from charging properly, which will in time result in a discharged battery. Also see that the generator protective fuse is intact.

Another possible, though hardly probable, cause is that the relay points remain closed after the engine has stopped. This would cause current from the battery to be dissipated in the generator windings. If this is the case, the contact may readily be broken by releasing

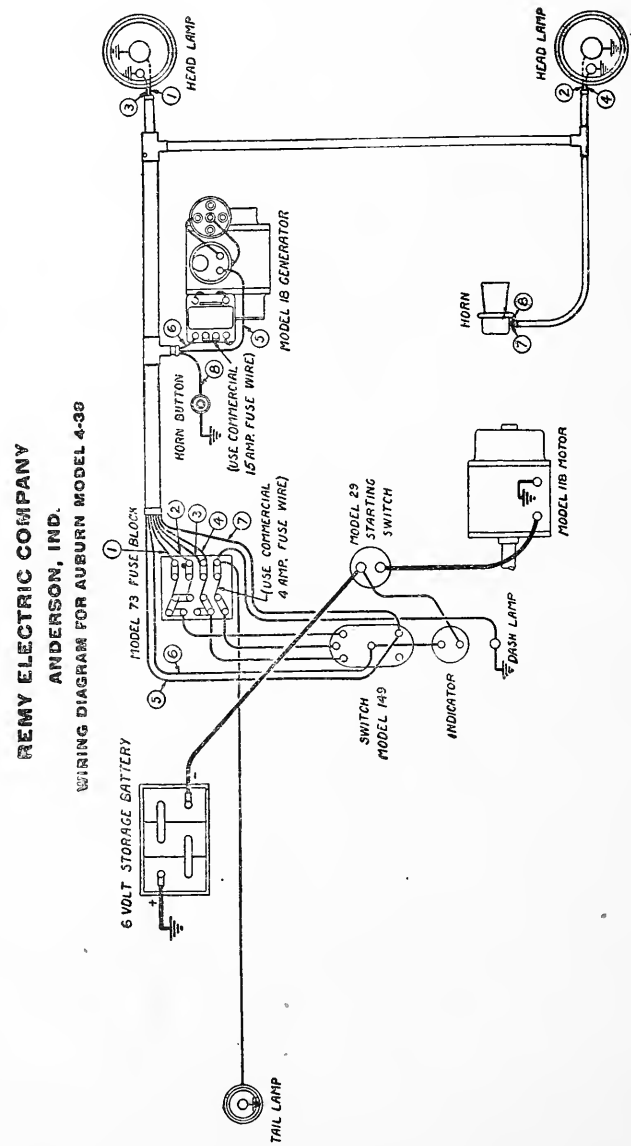


Fig. 34.

the relay arm with the finger. If the contact points are rough or pitted, they should be smoothed up with a piece of fine (00) sandpaper.

GENERATOR TEST

A simple test to determine if the generator is operating properly is, first, switch all lights on with the engine idle, then start engine and run same reasonably fast. If the lights brighten after starting the engine, it proves that the generator is properly delivering current. This test must necessarily be conducted in the dark, either in a garage, or preferably at night time.

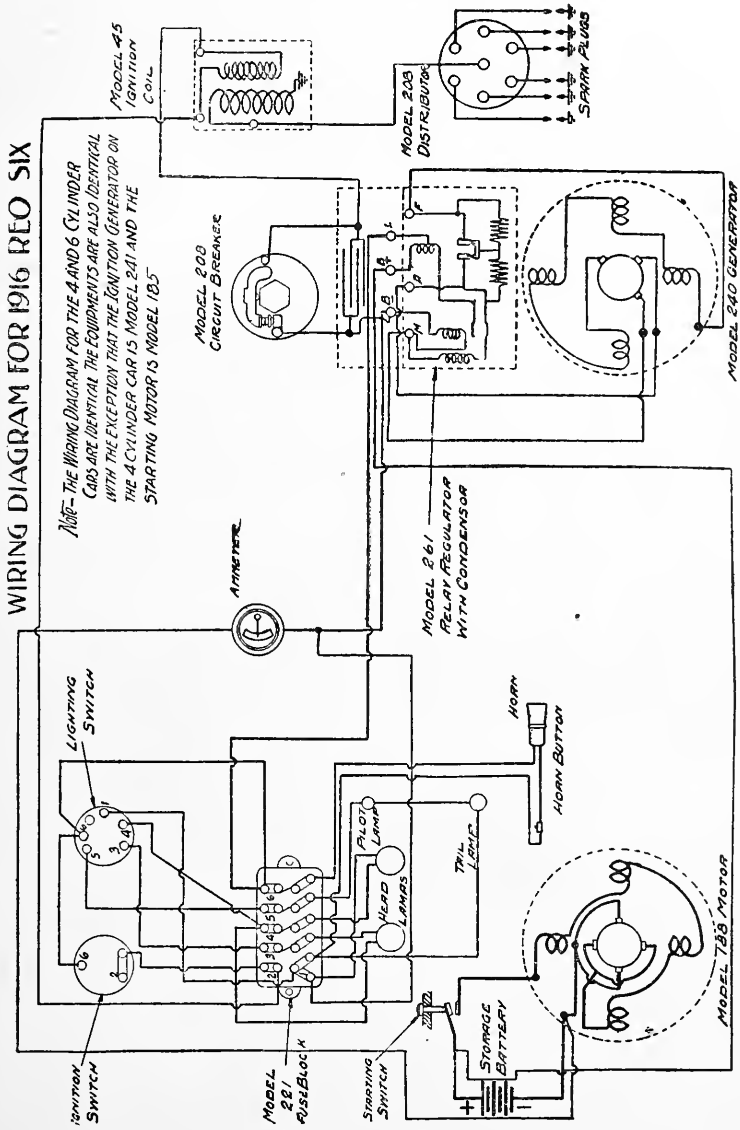


Fig. 35. Remy System.

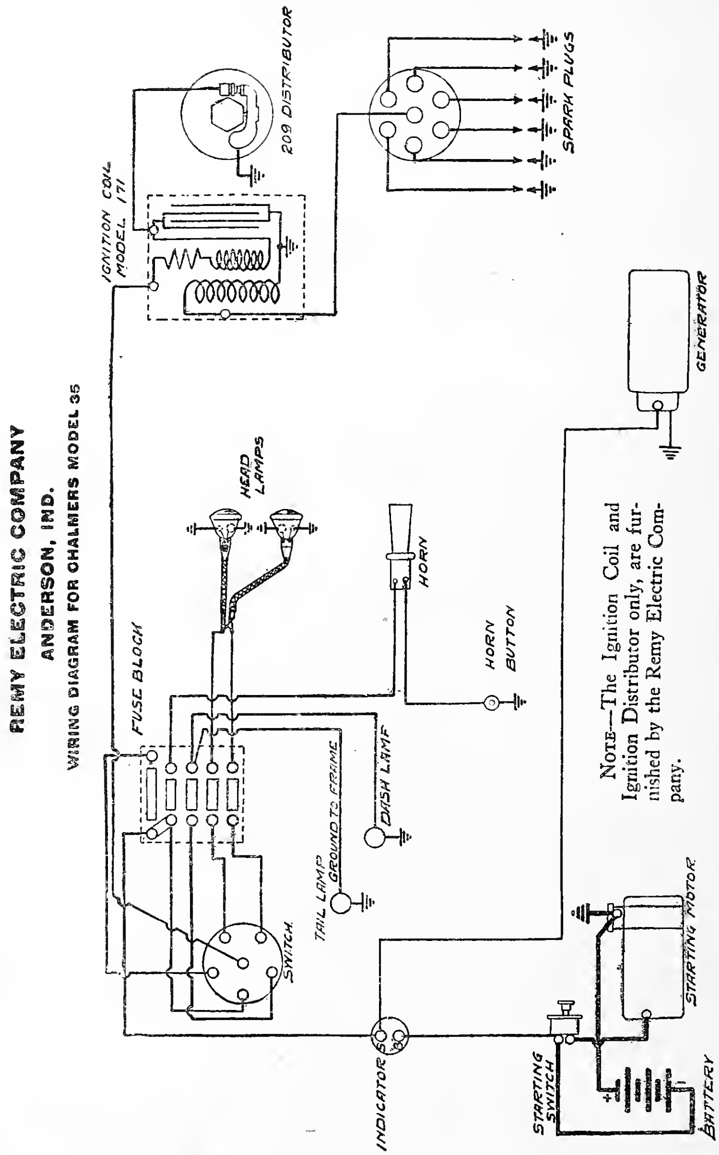

REMY ELECTRIC COMPANY
ANDERSON, IND.
WIRING DIAGRAM FOR CHALMERS MODEL 35
IGNITION COIL
MODEL 171
209 DISTRIBUTOR
SPARK PLUGS
GENERATOR
FUSE BLOCK
HEAD
LAMPS
HORN
HORN
BUTTON
DASH LAMP
TAIL LAMP
GROUND TO FRAME
SWITCH
INDICATOR
STARTING MOTOR
STARTING
SWITCH
BATTERY
NOTE—The Ignition Coil and Ignition Distributor only, are furnished by the Remy Electric Company.

Fig. 36.

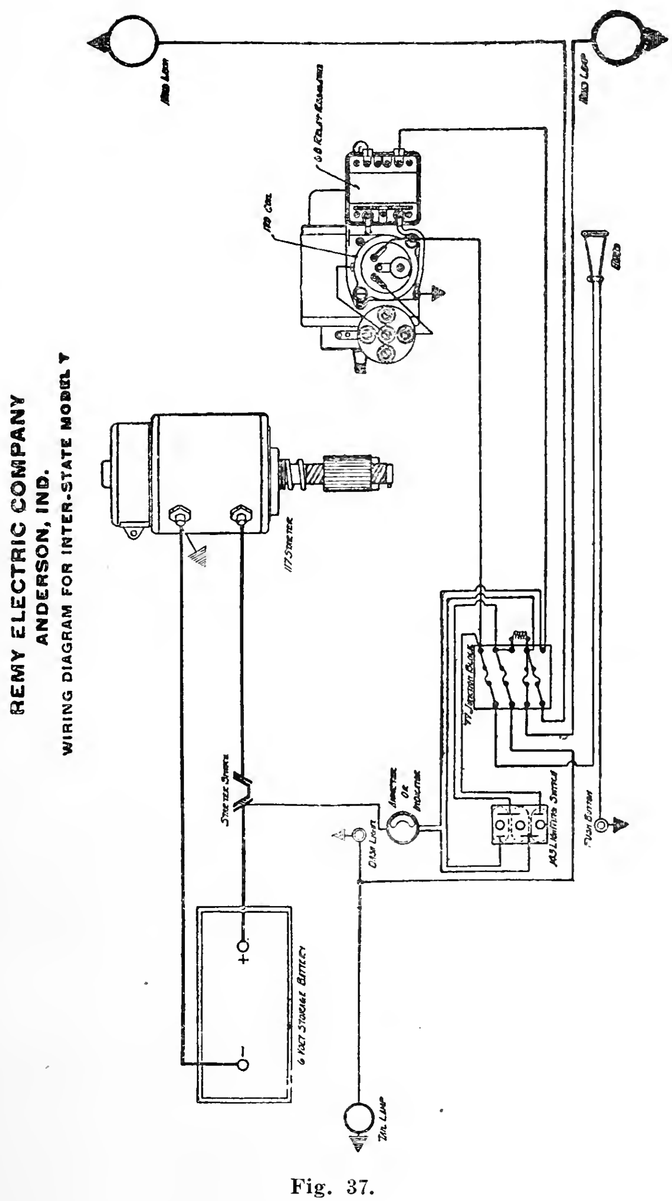

REMY ELECTRIC COMPANY
ANDERSON, IND.
WIRING DIAGRAM FOR INTER-STATE MODEL T

Fig. 37.

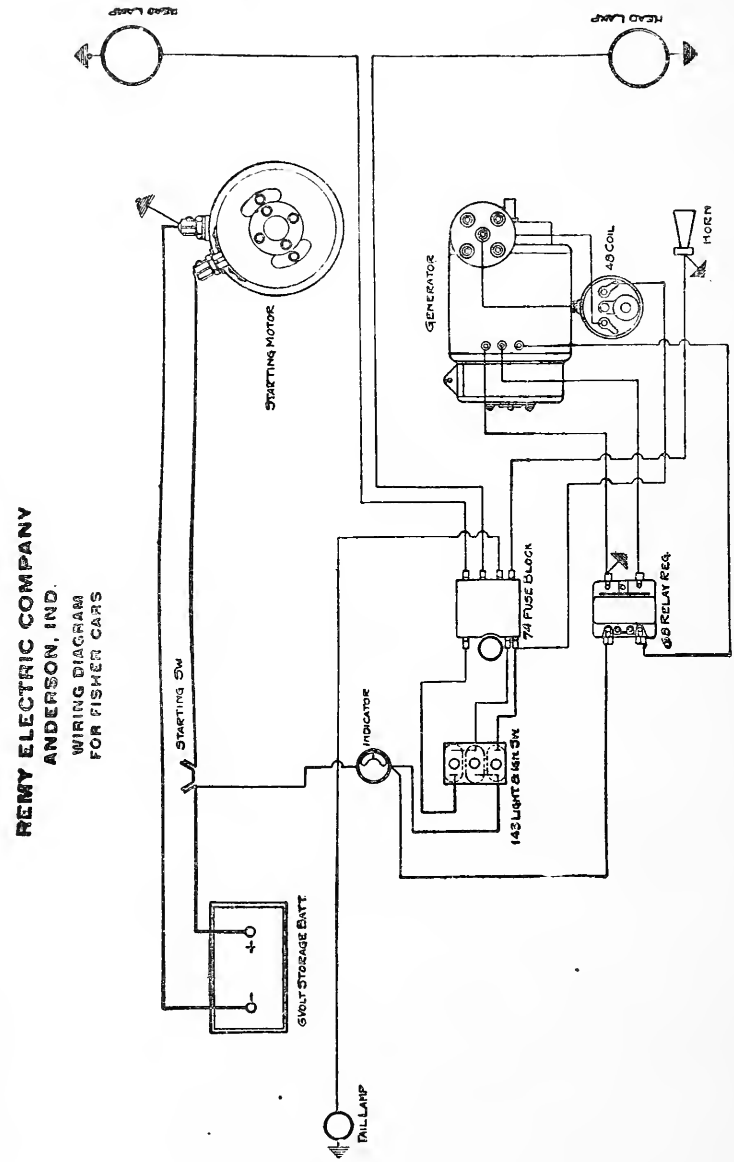

REMY ELECTRIC COMPANY
ANDERSON, IND.
WIRING DIAGRAM
FOR FISHER CARS
HEAD LAMP
HEAD LAMP
STARTING MOTOR
GENERATOR
48 COIL
HORN
74 FUSE BLOCK
68 RELAY REG.
STARTING SW
INDICATOR
143 LIGHT & IGN SW
6 VOLT STORAGE BATT.
TAIL LAMP

Fig. 38.

SIMMS-HUFF STARTING AND LIGHTING SYSTEM ON MAXWELLS

The Simms-Huff starting and lighting system is a so-called unit system, having a starting motor and charging generator combined in one. It is mounted on the left side of the engine, being geared to the fly-wheel by a sliding pinion when starting and driven by the fan belt from the front end when generating.

In starting the engine, the dynamo draws its heavy current from a 12-volt battery (2 halves, 6 volts each, in series) operating as a cumulative compound motor; that is, it has two field (shunt and series) windings, each acting to increase the torque of the motor. This gives maximum power for starting.

When the engine is running, the dynamo delivers its charging current (10 to 15 amperes) to the same battery at 6 volts (2 halves, 6 volts each in parallel), operating as a differential compound generator, that is, its two fields oppose each other, so that the terminal voltage and consequently the charging current is not excessive at the higher speeds. This likewise decreases the steady load on the engine, since torque developed through opposition of fields is considerably lessened.

The starting switch is bolted on the left side of the transmission case and is so arranged as to automatically connect the two halves of the storage battery in series (12 volts for motoring), or in parallel (6 volts for generating). With switch in position on the car and viewing same from the left side, large terminals on the top, number from left to right 1-2-3 respectively; on the bottom, from right to left, 4-5-6 respectively. The center terminals, Nos. 2 and 5, may be considered battery terminals; Nos. 1 and 6 motor terminals, and Nos. 3 and 4 generator terminals. The plunger within the switch box merely serves to connect terminals Nos. 5 and 6, also Nos. 2 and 1, when motoring, while connecting terminals Nos. 5 and 4, also Nos. 2 and 3, when generating.

The starting operation is further facilitated by a dual ignition system, whereby besides high tension current from the magneto, a dry battery and coil circuit is automatically inserted when switch is in starting position. This intensifies spark at low speeds.

The two contacts placed on the cover of starting switch afford connection to internal make-and-break switch, which is closed by the plunger head on starting and automatically opened when plunger falls back on generating side. Care should be exercised in seeing that circuit is closed between these two contacts, with switch in starting position, also that neither contact is grounded. (Note: On a few cars it has been found necessary to invert the cover in order to close ignition circuit on the starter side. Accordingly, therefore, the lettering on these covers will be inverted and ignition terminals will come on upper half of the cover.)

The storage battery used with this system is a Pumpelly 12-volt battery, split in halves to permit of increased voltage on starting. Each half is a distinct 6-volt battery in itself, but both are contained in a single case and mounted underneath the front seat. Assuming the driver's position in a car, that half farthest to the right is designated "R," that to the left is designated "L." In this manner the negative terminal of the right half is designated "—R," the plus terminal of the left half "+L," etc.

CUT-OUT RELAY

On all generating systems involving the use of the generator and storage battery together, it is essential to provide some means of preventing the latter from discharging into the former when engine is at a standstill, or whenever terminal voltage in the former falls below that of the battery. To this end the cut-out relay is inserted in the charging circuit and is equipped with a compound shunt and series winding. As the generator voltage builds up, the current through the shunt winding closes the cut-out and permits the generator to charge into the storage battery. However, when generator voltage falls below that of storage battery, current coming from the latter through the series field of the cut-out automatically demagnetizes the core and circuit leading to generator is opened. This prevents ultimate discharge of the battery from this source.

The main cut-out contacts are of spring copper with auxiliary contacts of carbon. The arrangement is such that the carbon contacts always make-and-break before the copper con-

tacts. In this manner all arcing is borne by the carbons, leaving copper contacts clean and free to carry the higher currents.

BELT REGULATION

In a system where only a cut-out relay is used, it is important that the tension on fan belt driving generator be regulated so as to show proper charge on ammeter at the dash. A relative rate of charging would be from 8 to 15 amperes. When the car is used for country

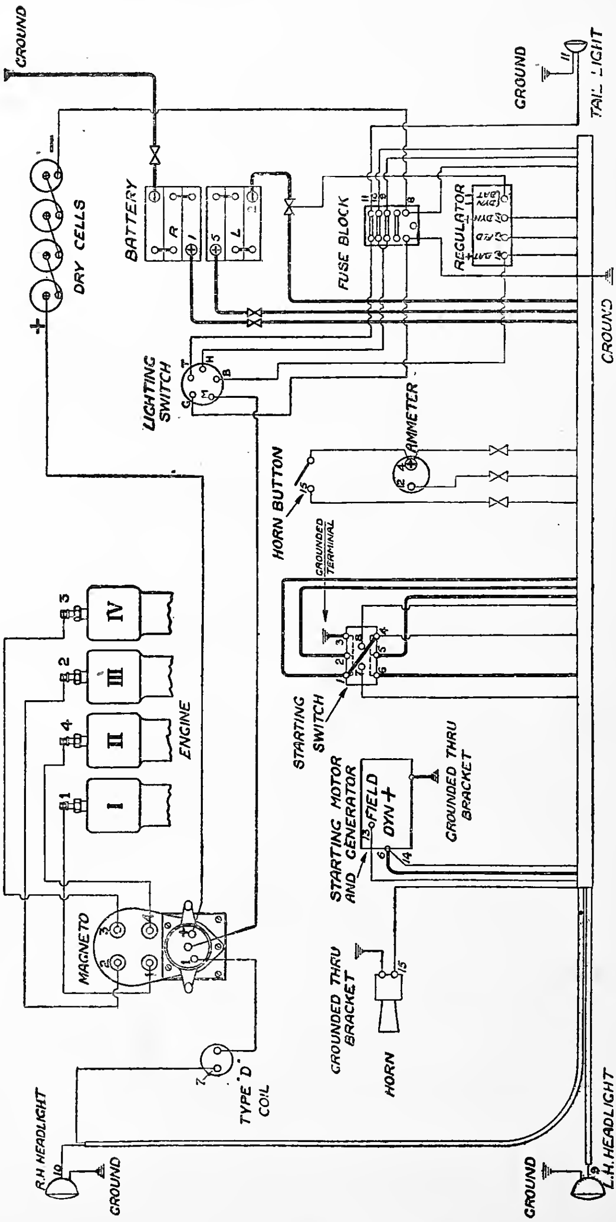


Fig. 39. Simms-Huff System.

work and touring where the electric lights are not used to any great extent, a charge of 8 amperes is sufficient. However, if the car is used in the city and frequent use of the starter and lights is necessary, the charge should be nearer 15 amperes. Briefly, if the ammeter shows a charge of less than 8 amperes the belt should be tightened. Suitable adjustment is provided by a slotted segment and set bolt on the fan support, whereby belt tension can be varied considerably. A tight belt, of course, tends to speed generator up and increases the charging rate, while a loose belt increases slippage, thereby decreasing charging rate.

The combination cut-out and regulator serves the double purpose of the cut-out relay and belt tension for regulation. It is essentially two distinct relays, one serving precisely the same as the cut-out relay described above, the other serving to regulate the amount of charge from generator to storage battery, regardless of belt tension. To accomplish this last step the shunt field of the dynamo is brought into the regulator at terminal marked "FLD." By means of vibrating contacts an additional resistance is automatically cut in the dynamo field when voltage rises, and cut out when dynamo voltage lowers. In this manner, dynamo, when generating, is made to hold practically constant voltage, with subsequent constant charge into the battery. It must be understood, however, that belt tension must be at least sufficient to give generator proper speed for charging current, as regulator is only intended for possible excess charge.

ELECTRICAL CONNECTIONS

In the wiring of the car it will be noticed that all wires for starting service are heavy cables inserted in separate looms. Cables for generating and lighting circuits are of smaller gauge and are inserted collectively in single loom.

SPLITDORF-APELCO ELECTRIC STARTING AND LIGHTING SYSTEM

The Splitdorf-Apelco Starting and Lighting System as a single unit consists of a motor-generator, indicating automatic switch and starting switch, together with a 12-volt storage battery.

By connecting the motor-generator across the terminals of the battery through the starting switch, the machine acts as a motor, cranking the engine until it runs from its own power. The motor-generator is then driven by the engine as a generator, furnishing current for charging the battery and other demands. The armature is carried on ballbearings. Sprockets and silent chain are used for driving the starting and lighting unit, no additional reduction being necessary than that secured through the sprockets.

The current output of the generator is controlled by special field windings. This inherent regulation feature makes it impossible to charge the battery at too high a rate and also eliminates the uses of other regulating devices. The indicating automatic switch is connected in the circuit between the generator and the battery. Its function is to make connection between these two units when the voltage of the generator is higher than that of the battery. In other words, the switch automatically closes when the generator is being driven at sufficient speeds to charge the battery, allowing the current generated to flow to the battery. When the generator speed is not high enough to produce a current high enough in voltage for charging the battery, or the engine is stopped, the switch automatically opens, disconnecting the generator from the storage battery. This instrument is equipped with an indicating dial which shows the lettering "Charge On" when current is flowing to the battery, and "Charge Off" when battery is not being charged. This switch is mounted on the dash. The starting switch is used for starting purposes only. A 12-volt storage battery is used in connection with this system. The battery supplies 12-volt current to the motor-generator at the time of starting, as well as 12-volt current for lighting purposes. Fourteen-volt bulbs should be used in connection with this system for all purposes excepting where the tail light is in series with dash light; in this case use 7-volt lights in this circuit only. The most important points are:

Oil holes are provided at the ends of the generator for lubricating the bearings. A few

drops of machine oil every two or three weeks is all that is necessary. Examine the commutator occasionally to see that it is clean and bright, as well as free from oil. Any dirt can be removed with a piece of 00 sandpaper. Emery cloth should never be used. The indicating automatic switches are properly adjusted at the factory. If for any reason, however, they fail to register properly, consult the nearest Splitdorf-Apelco service branch. Fig. 40 shows a general wiring diagram of the system.

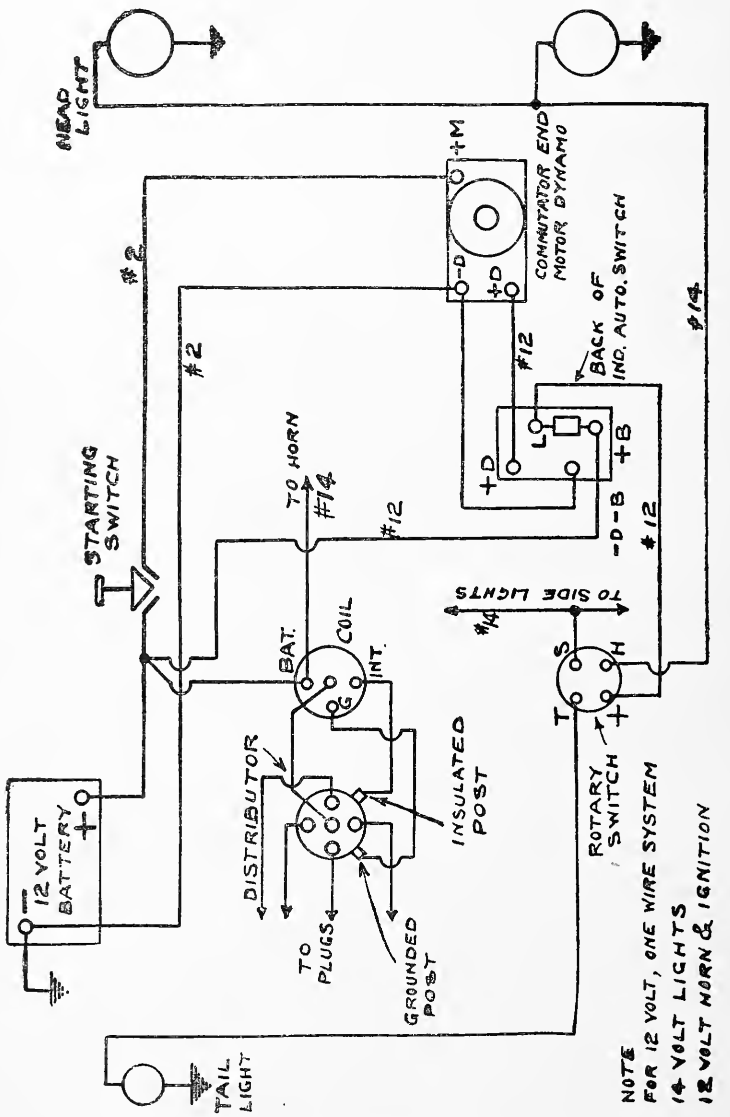


Fig. 40. Splitdorf-Apelco System.

THE WAGNER STARTER AND GENERATOR

The Wagner System consists of motor, generator, starting switch, and storage battery. The motor is a simple wound machine, and is in use only when the engine is being cranked by it. The generator is an especially wound machine and requires no regulators or external controlling devices. Fig. 47 gives a general wiring diagram of the system. The only controlling device used in connection with this system is the automatic cut-out, which connects and disconnects the generator to the system at the proper time. The instructions given us by the manufacturer of this system are as follows:

The starter will not start the engine if the **battery** is not in reasonably good condition.

If the starter makes no attempt to start whatever, and everything seems to be O. K., including battery, etc., there may be an **open circuit** in the wiring leading from the battery to the starter. With an open circuit, the starter cannot start, and the remedy is to locate this open circuit and fix it. Examine all wires carefully and look for **breaks in the wires.** Also examine the connections and look for **loose connections.** This open circuit might possibly be in the switch, due to contacts not touching properly. To determine this condition easily remove one of the wires leading to the switch and place this wire on the one still connected.

If the starter **does not** then start, it indicates that the contacts inside of the switch are O. K., but if the starter **does** start, it indicates that the contacts inside of the switch do not touch properly and the switch should be removed from the car for examination. The contacts should bear against each other with a moderate amount of pressure, thereby insuring good contact. If you find that these contacts do not touch, or that they are burnt or in bad condition, you can either repair them or obtain new contacts to replace them.

The brushes on this starter were set at the factory in the proper place, and changing this brush setting will not help the starter. You should, **under no condition,** change this brush setting.

The commutator and brushes are located on the front of the starter, underneath the cover. This cover should be removed from time to time for the purpose of inspecting the condition of the commutator and brushes. This commutator should be smooth and clean, and the brushes should bear on the commutator with a moderate amount of pressure. The brushes should be well seated; that is, they should touch along their full length so as to insure good contact.

If you find the commutator **dirty** or **rough** it should be smoothed up and cleaned with fine-grained sandpaper and cloth. **No lubricant is to be used,** as the brushes are self-lubricating. Application of vaseline or grease is harmful, as all forms of grease possess insulating qualities to a greater or less extent.

If the starter continues to revolve after the engine fires, examine the heel switch. If this switch is stuck so that it did not open when you released it, the starter is still connected to the battery and will continue to run until this switch is opened. If you find that this switch is **open** and the starter still running, the trouble is with the roller clutch on the engine.

You should under no circumstances add **special switches** or **devices** to the starting equipment. It is very likely that you will not put these devices in the circuit properly and thereby cause the starter to fail. The switches, etc., employed in this system are of special construction, suitable for operation in 6-volt circuits, and if you add appliances which are not suitable for the service you will not get satisfactory results.

Failure to start may be caused by a **short circuit** in the field or armature of starter. This short circuit can usually be detected by excessive heat in the starter and possibly smoke coming from the starter when the starting switch is closed. A short circuit may also manifest itself by a low starting power with a **full** battery. If the starter is found to contain a **short circuit** or **ground,** it should be sent to a repair shop for repairs. If this cannot be done locally, it should be returned to the factory.

The ball bearings should be kept lubricated with a good grade of machine oil, using about 6 drops per 1,000 miles. If these bearings are not kept lubricated they may become worn, which will allow the armature to rub on the field. Should the starter be in this condition it will not start, and the remedy is to supply new bearings.

The starter should be kept free from **excessive moisture.** Ordinary moisture will not

hurt the starter, but it should not be allowed to become thoroughly wet, such as would be the case if the starter were to become submerged in water. This is likely to happen while fording a stream. If you find that the starter has been submerged, do not attempt to use it until it has been removed from the car, the commutator cover removed and baked 24 hours in an oven whose temperature shall not exceed 220° Fahrenheit. A higher temperature in the baking would damage the insulation. If this baking process is not successful, it will be necessary to send the starter to either a first-class local repair shop or to the factory for repairs.

If there is reason to believe that the relay on the generator is not operating properly, or that the generator is not charging properly, place an ammeter in circuit and make the test recited below, which tells how the relay, tell-tale, and ammeter **should** act. Be sure that the ammeter is so connected that it will read in a **forward** direction when the generator is charging and the tell-tale indicating **charge.**

The test should be made with **all lights out** and **ignition** on the **dry** cells, because then the relay and tell-tale will act simultaneously, and therefore the tell-tale will serve as an indicator showing how the relay is acting.

The ammeter needle should stand at **zero** and the tell-tale should show "off" when the generator is not running. The relay is now open.

Start the engine and speed it up **slowly.** This ammeter needle should remain at **zero** and the tell-tale should remain **off** until the engine speed is equivalent to a car speed of **7 to 10** miles per hour. At this speed the relay should **close** and the ammeter needle will **register** the charging current, and the tell-tale should show **charge** as soon as the relay **closes.**

Throttle the engine slowly and note the ammeter needle. When the speed has been decreased sufficiently, the ammeter needle will read **backwards** and the tell-tale will show **discharge.** This discharge current shown by the tell-tale will only last for an instant, because the relay will then **open** and the ammeter needle should read **zero** and the tell-tale show **off** as soon as the relay **opens.** This relay should open at an engine speed equivalent to a car speed of **5** to **8** miles per hour.

If the action of the ammeter and tell-tale does not correspond according to the above, be guided by the ammeter indication as showing how the relay is acting.

If the above test shows that the tell-tale indicates discharge **continually** and the ammeter verifies this by reading **backwards,** it means that the relay is out of adjustment. This could also be caused by the relay being stuck at the points so that the relay cannot open.

If the tell-tale indicates **discharge** when **all lights** are **out,** horn not blowing, ignition switch open, and the ammeter reads **zero,** it means that there is a short circuit or ground somewhere in the system which will drain the battery. This is provided the tell-tale **is not stuck** and is indicating correctly.

If the relay **does not close** according to the above test, there is probably trouble in the relay, but more likely the commutator and brushes are rough or dirty.

If the above test shows that the relay **closes** (by observation) properly, but that the generator furnishes **no current,** shown by the ammeter reading **zero,** it means that the relay contact points do not make contact. Examine these contact points and if they are burnt beyond repair, a **new relay** should be substituted. **The generator must not be used with the relay in this condition, as it is likely to be damaged.** If the car must be used until a new relay can be substituted, remove the damaged relay and ground the generator terminal. Remove the ground wire when the new relay is installed. This must be done with the engine **standing still.**

You should not attempt to make adjustments of the relay, but substitute a new one.

The commutator and brushes should be kept perfectly smooth and clean. If the generator refuses to charge it might be due to **dirty commutator and brushes,** or possibly due to a **rough commutator,** both of which will cause **bad contact.** The cover should be removed from time to time to inspect the condition of the commutator and brushes. If they are found to be dirty or rough, they should be smoothed up with fine-grained sandpaper and cloth.

To clean the commutator, speed your engine up to about 1,000 revolutions per minute

and wipe off the commutator with a piece of cloth dampened with kerosene, so as to remove grease and dirt. If the commutator is apparently rough, hold a piece of very fine sandpaper, grade 00, on the commutator while the generator is running. Move the sandpaper back and forth across the face of the commutator so as to smooth it evenly. **Do not use** emery cloth.

To clean the brushes it is not necessary to remove them from the holders. Lift the brushes and wipe off the surface with a piece of cloth dampened with gasoline. If the brush surface is apparently rough insert a piece of sandpaper, grade 00 (rough side toward the brush), under each brush separately and then let the brush press on the sandpaper. Draw the sandpaper back and forth across the commutator, taking care that it is held in such a way that it conforms to the curvature of the commutator.

Do not use the sandpaper on either commutator or brushes without first trying to get results by wiping off the dirt as outlined on preceding page.

No lubricant is to be used, as the brushes are self-lubricating. Application of vaseline or grease is harmful, as all forms of grease possess insulating qualities to a greater or less extent.

Dirty or rough commutator can be detected by connecting in circuit a low reading voltmeter (scale 0 to 30 volts). Connect one terminal of the voltmeter to terminal (X) and the voltmeter terminal to the generator foundation bolt. Then speed your engine up to a speed corresponding to a car speed of 15 or 20 miles per hour. This voltmeter should show (6) volts or more and the relay should be **closed,** showing **charge** on the tell-tale. If this voltmeter does **not** show (6) volts or more it indicates a dirty or rough commutator or else an open circuit in the shunt field. Press down lightly on the brushes while the generator is running, and if this causes the voltmeter to indicate and the relay to close, the trouble is **bad brush contact.** If the voltmeter **cannot** be made to indicate and the relay to close by cleaning the commutator and pressing on the brushes, the trouble is probably an **open circuit** in the shunt field, which will have to be repaired either locally or by sending the generator to the factory.

If the voltmeter **does** show (6) volts or more, or can be made to show (6) volts or more by pressing on the brushes or by cleaning the commutator and brushes, and the relay **will not close,** it means that the relay is **not in proper adjustment** and a new one should be supplied.

The tension spring **should not be changed** either intentionally or accidentally, as this will throw the relay out of adjustment.

If the battery continues to run down, and apparently the generator does not charge fast enough to keep the battery full, it might be well to measure the charging current as follows:

Place an ammeter in circuit, using No. O-B & S **copper cable** in just as **short lengths** as possible. Place a voltmeter, scale 0 to 30 volts, in circuit by connecting one terminal of the voltmeter to the terminal (X) of the generator. Connect the other terminal of the voltmeter to one of the foundation bolts (Y) on the generator by raising this bolt and then tightening it down on the wire.

Start the engine and take readings of amperes and volts for car speeds up to 25 miles per hour, taking several readings between 8 and 25 miles per hour. The maximum charging current should be about 17 amperes with a corresponding generator voltage of 8.6 volts, and this maximum current should occur at a car speed of from 15 to 20 miles per hour. The charging current will decrease at higher car speeds so as not to overcharge the battery while touring at fairly high speed.

If you find that the maximum charging current is **materially lower** than the above values, it does not necessarily mean that the generator is improperly set, but more likely means that the battery is **sulphated,** due to standing idle without attention, or else the **generator brushes and commutator need attention.** If the commutator and brushes

are put in good condition, and if the battery is fully charged and free from sulphate, the generator amperes and voltage will rise back to the values given above.

If, on the other hand, you find that the charging amperes and voltage are **materially higher than the above values,** it very likely means that there is some unnecessarily high resistance in the charging circuit. You will very likely find one or two **loose connections** on the generator, relay, battery, or indicator, which have come loose due to vibration. If these loose connections are tightened, the charging current will very likely drop down to normal.

Be sure to use No. O-B & S copper wire or larger, for the ammeter connections and make them as short as possible. If smaller wire is used, the increased resistance will act the same as a loose connection, and your test will be incorrect.

If you find that the charging current is O. K., but will not keep your battery up, it means that you should note the size of your lamps to see if they are the same size as those furnished with the car. If you find that the lamps are of the same size as those furnished with the car, and still a peak charging current of 17 amperes at 15 or 20 miles per hour will not keep the battery charged, the driving conditions are probably responsible for the trouble. This assumes that the battery is in first-class condition.

If a great deal of slow driving is done at night with all lights burning, and if it is necessary to let the car stand at the curb with all lights burning, this will demand an excessive current from the battery. This same amount of current must be put back into the battery and the engine run long enough to do this. In other words, the car must be driven enough in the day time to put back into the battery what is taken out at night. If driving conditions correspond with this schedule, this matter should be taken up with the manufacturer of the car, or some other provision must be made for this class of service. Always turn out the headlights when the car is standing still and is to remain standing for some time.

The generator must be kept free from excessive moisture. Ordinary moisture will not affect the generator, but it should not be allowed to become thoroughly wet, such as would be the case if the generator were to become submerged under water. This is likely to happen while fording a stream. If the generator is wet it should not be operated until it is thoroughly dried out.

The condition of the battery is **absolutely essential** to the operation **of the generator, lights,** and **starter.** It is, therefore, essential that you have your battery in good condition.

If it ever becomes necessary to operate the car with the battery removed from the car, take a piece of No. 10 copper wire and connect one end of this wire to generator terminal (X). Connect the other end of this wire to the generator frame by raising up one of the foundation bolts at (Y), and then tightening the bolt down on the wire. Be sure that you have good metallic contact at both points (X) and (Y).

When you replace the battery on the car and reconnect it, be sure to remove this wire.

TESTS FOR GROUNDS AND SHORT CIRCUITS

The following test will enable you to locate **short circuits** in different portions of the starting and lighting system:

Disconnect the wire from the generator and **disconnect** the two wires from the starter. **Disconnect** entirely one terminal of the battery and connect these wires to one terminal of an ammeter reading at least 0 to 20 amperes. Connect a piece of wire to the other terminal of the ammeter, and hold the other end of this wire in the hand ready to touch the battery terminal, which has been disconnected, according to the following:

With the starter and generator disconnected, all lighting switches open, ignition switch open, and horn not blowing, touch the ammeter wire to the battery terminal. If the ammeter registers any current, no matter how little, it means that there is a short circuit in the

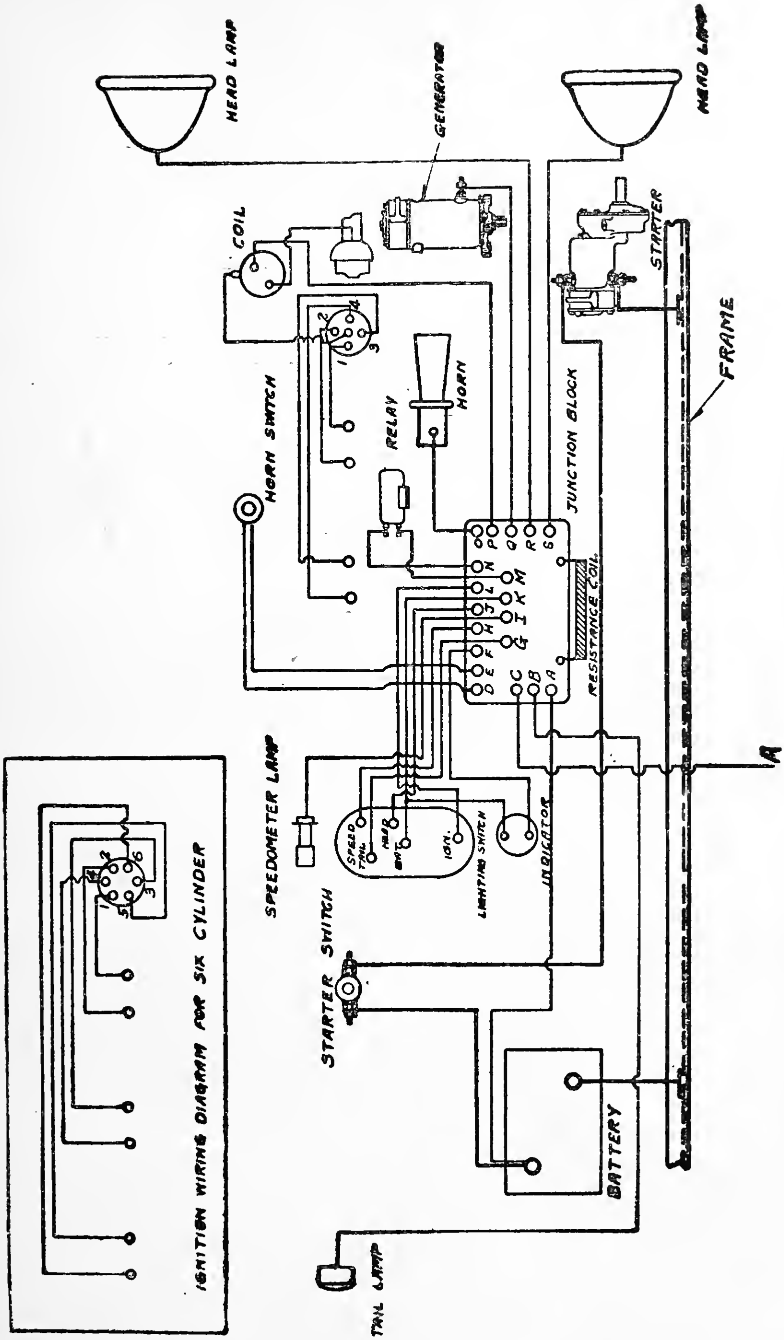


Fig. 47. Wagner System.

wiring of the car somewhere between the battery, junction box, generator, or starter. If the ammeter shows a heavy current, it means a severe short circuit.

Reconnect the wire to the generator and touch the wire to the battery terminal. If the ammeter **indicates** current, it might be due to the relay being **stuck** at the **points.** Examine this relay, and if it is found to be open and not stuck, and the ammeter still registers current, it means that there is a short circuit somewhere in the generator **windings.**

Disconnect the generator again, **remove all lamps** from the sockets, and then turn on each lighting circuit separately and note the **indication** of the ammeter, touching the ammeter wire to the battery terminal. If it is found that with any one lighting switch turned on the ammeter registers current, it means that there is a short circuit on that particular lighting circuit.

Do not under any consideration close the starting switch with the ammeter in circuit, as the current required by the starter will damage the ammeter. To test for a short circuit in the starter, you should remove the ammeter and replace the wires on the battery as before and then start the engine in the regular way. A short circuit in the starter will usually manifest itself by low starting power, and possibly smoke coming from the starter winding. The battery must be fully charged for this test.

If you find short circuits in any part of the system according to the above test, these short circuits should be removed by insulating the places where the short circuits occur.

Caution: Do not experiment with the starting and lighting system. The tests enumerated herein are meant to be used in locating trouble. If the starting and lighting system is working satisfactorily, let it alone except for necessary oiling of the bearings on the starter and generator. If actual trouble occurs, then is the time to resort to these tests.

If you are not getting satisfactory results from your starting and lighting system, and if you cannot locate the trouble by following these instructions, drive your car to the nearest **Studebaker Service Station.** They have competent men to serve you. If you cannot locate your trouble they can call on the Wagner Co. for the service of an **expert.**

There will be no expense attached to this service if the trouble has been caused by a defect in the system, but there will be a service charge if the trouble has been caused by neglect, or if the service rendered is in the nature of **"up-keep."**

THE WARD LEONARD CONSTANT CURRENT DYNAMO CONTROLLER

The controller performs three different functions, regulates the voltage and output of the generator, and connects the generator into the system and disconnects it from the system at the proper time. This device is used in connection with a number of prominent makes of systems used on motor cars. The skeleton diagram shows the circuits of the controller and the connections to a simple shunt wound generator and storage battery. There are four terminals on the regulator and they are marked A, D, B, and C. The following instruction in regard to this controller is as given us by its maker. See Fig. 48.

THE WARD LEONARD AUTOMATIC CONTROLLER

This controller automatically keeps the dynamo output constant regardless of the engine and dynamo speeds, and embodies as part of it an automatic switch which properly connects and disconnects the dynamo to the battery.

In a dynamo its energy output increases with the speed unless a method of controlling it is adopted. With the Ward Leonard Controller the energy output of the dynamo to the battery is made to control itself by causing a series of recurrent fluctuations of energy to pass to the battery.

Refer to cuts: The energy output of the dynamo passes through the series switch winding "F." When 10 amperes is reached it attracts its keeper "H" and opens the circuit at "EE,"

thereby inserting a resistance "M" in series with the dynamo field. This weakens the field and reduces the dynamo energy output. When the amperes decrease to, say 9 amperes, the coil "F" is not strong enough to hold the armature "H" against the action of the spring "J" and the contact "EE" is made again, short circuiting the resistance "M." This increases the field strength and the dynamo output tends to increase. When it is increased to 10 amperes the contacts "EE" are opened, inserting resistance "M." This same cycle of operation of inserting and shunt resistance "M" keeps occurring as the dynamo speed is increased. Under operating conditions the finger (H) automatically and rapidly vibrates at such a rate as to keep the voltage constant.

The voltage switch "DD" connects the dynamo to the line when the dynamo voltage is greater than the battery voltage and disconnects the dynamo from the line when the battery voltage is greater than the dynamo voltage.

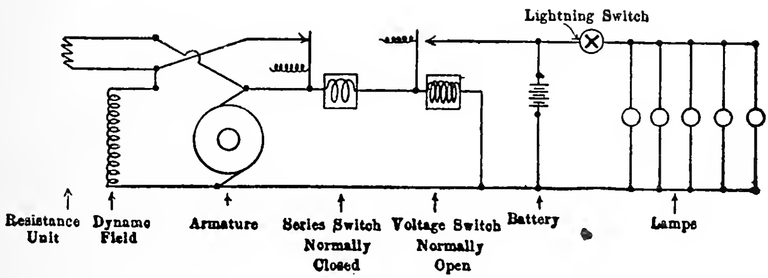


Fig. 48. Ward-Leonard Regulator.

SECTION 7

MAGNETOS

MAGNETOS

Contains General Information Concerning Magnetos Used on Motor Cars.

Information, Instruction, and Wiring Diagrams of Simms Magnetos of the Independent, Dual and Water Proof Types S U 4, S U 6, S U 4 D, S U 6 D, S U 4 S, and S U 6 S.

Information, Instruction and Wiring Diagrams of Bosch Magnetos of the D U and S R Types, Bosch Two Independent System, Bosch Vibrating Duplex System and Bosch Duplex with L A 2, M A, L A I, N A I, and N U Coils.

Information, Instruction, and Wiring Diagrams of Mea Magnetos of the Dual Types, S S, S C and S C 2.

Information, Instruction, and Wiring Diagrams of Eisemann Magnetos of the E B Types with B D Coil, E A, E U and E D Types with Manual Control in connection with D T, D 2 U, and D C R Coils. Automatic Spark Control Types E R A, E D A and E U A with D C R Coils, Eisemann High Tension Dual System with E M, D C, and D C R Coils.

Information, Instruction, and Wiring Diagrams of Remy R D Perfected Inductor Types and Types R L with L E Coil or L C Coil with D or H Switch.

Information, Instruction, and Wiring Diagrams of Splitdorf Magnetos of the A, A W, A X, W, X and Z Types.

MAGNETOS

For ignition purposes, in connection with internal combustion engines, the magneto is considered a very efficient and reliable device. There have been three types of magnetos in use for quite a time, which are:

1. The low tension magneto in connection with step-up coil, furnishing a jump spark.
2. Low tension magneto in connection with make and break system.
3. High tension magneto, furnishing a jump spark.

The low tension magneto in connection with the make and break system is generally used on stationary engines, so we will not discuss it here.

A low tension magneto has but one winding on the armature, which is called the primary. This magneto generates a low voltage current at all times. In order that the current be raised to the right voltage, an induction (step-up transformer) coil is used in connection with it.

A high tension magneto has two windings on the armature. They are called the primary and secondary windings. In the operation of this type of magneto, current is induced into the secondary winding from the primary, thereby raising the voltage as desired.

A condenser is used in connection with all jump spark ignition systems. With the low tension MAGNETO system it is generally made as a part of the coil. With

the high tension MAGNETO system, it is generally located in the armature. The condenser assists in eliminating sparking at the platinum breaker contacts, and assists in increasing the voltage of the secondary current.

In either the high or low tension magneto systems, a spark is produced for ignition purposes when the interrupter or breaker contacts open.

In the dual systems a storage battery or set of dry cells is used as a source of energy for the battery part of ignition. In some instances the same interrupter contacts are used for both magneto and battery ignition, while in others two separate interrupters are employed. Where both systems operate on the one interrupter, ignition spark is produced when the interrupter contacts open. When two separate interrupters are employed, ignition on the magneto side occurs when the interrupter contacts open, and on the battery side ignition takes place when the interrupter contacts close, with only a few exceptions.

There is very little difference in the timing of magnetos, whether of the high or low tension types. The setting as a rule is as follows: Crank engine until piston in cylinder No. 1 is at top dead center or on full compression stroke. Set magneto armature in position so that the interrupter contacts are just starting to open. Make high tension connections in the usual way. While the instructions for setting and timing of magnetos are given in many different ways, there is not a great lot of difference in their timing. It is well, however, to follow the instruction given by the maker, if such is to be had, but the above instruction will always work out very good with all magnetos.

Magnetos of different makes and different types require different settings or adjustments of the breaker (interrupter) contacts and the spark plug gaps. The following adjustments cover all of the systems shown in this book:

Bosch Systems.

Set interrupter contacts to open from .015 to .016 inch. Set spark gaps about .020. There may be a slight difference in the various types, but this setting will prove very satisfactory under nearly all conditions.

Eisemann Systems.

Type E. M.—Breaker contacts open .015 inch; spark plug gaps from .015 to .030 inch, the spark gap depending upon characteristics of engine. **Types ERa, EDa,** and **EUa**—Breaker contacts should open not more than .015 inch; set spark plug gaps from .015 to .018 inch. **Types E.A., E.U., and E.D.**—Set breaker contacts to open from .015 to .020 inch; set spark plug gaps .016 inch. **Types E. B.**—Set breaker points between .015 and .020 inch; set spark plug gaps from .025 to .030 inch.

Mea Systems.

Breaker points should open from .015 to .017 inch; spark plug gaps should be about the same distance.

Simms Systems.

Set interrupter contacts to open about .015 inch; set spark gaps opening about .020 inch.

Splitdorf Systems.

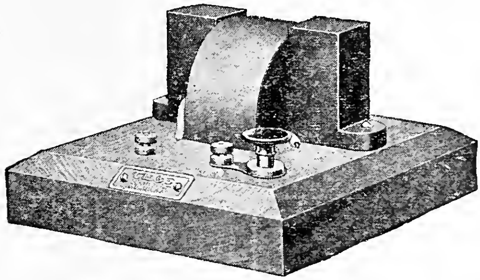
Set breaker points to separate about .025 inch; set spark plug gaps not to exceed .030 inch.

Remy Systems.

Set breaker contacts to open between .025 and .030 inch; set spark plug gaps with same opening.

MAGNETIZER or (MAGNET CHARGER)

Operates from a Six Volt Storage Battery



In meeting a long-felt want for an instrument to give new life to tired or lazy magnetos, we offer the Auto Magnetizer or Magnet Charger which is designed to operate from an ordinary **six-volt storage battery** or five or six ordinary dry cells. With a fully charged 6-volt 60-ampere battery, 75 to 100 magnetos can be remagnetized.

It is a recognized fact among magneto manufacturers that for a magneto to give its maximum efficiency indefinitely the magnets should be charged or remagnetized occasionally.

Complete instructions for operating accompany every outfit.

Positively guaranteed. Price $10.00.

AUTO ELECTRIC SYSTEMS PUB. CO.
Dayton, Ohio.

BOSCH "TWO INDEPENDENT" SYSTEM.

The Bosch "Two Independent" system provides a means by which the engine may be started on the press button or at a very low cranking speed, and the battery system is available for emergency ignition, in case of accident to the magneto.

In order that the system may be employed, locations for two sets of spark plugs must be provided, and there must be a drive for the magneto at proper speed, as well as a drive at cam shaft speed for the timer-distributor.

Any of the standard models of independent Bosch magnetos may be used, no change whatever being necessary.

The battery system consists of a combined coil and switch, and a timer-distributor, which are completely independent of the magneto.

The two systems are brought together at the switch, and the connections are such that the engine may be operated on the magneto with one set of plugs, or on the battery with the other set of plugs, or on the battery and magneto together, in which both sets of plugs will spark. The battery or magneto system may be used for ignition with the other system entirely dismantled or removed from the engine.

Installation.

In installing the Bosch two independent system, it is necessary that the interrupter of the magneto and the circuit breaker of the timer-distributor break their respective circuits at the same moment. It is only under this condition that the simultaneous operation of the two systems by throwing the switch to the position "MB" will be effective.

The first step is to set the magneto in accordance with the instructions given for that particular type. The only new parts of the two independent system are those operated by the battery, and the handling of the magneto is in exact accordance with the instructions given for the independent instruments.

The next step is to set the timer-distributor in synchronism with the magneto.

The distributor-plate of the timer-distributor should be removed, which is done by loosening the side springs. This will permit the movement of the circuit breaker lever to be observed. The timer-distributor is to be placed on the shaft arranged to drive it, with the sleeve loose, and timing control arm is to be connected to the control rods in the usual manner. The arrangement of the control apparatus is usually such that its movement will cause a corresponding and simultaneous movement of the timer-distributor and magneto control apparatus. The timing control lever should be placed in the full advance position, and the motor cranked until it is observed that the magneto interrupter is in the act of breaking.

Sleeve shaft of the timer-distributor should then be revolved in the direction in which it will be driven, until timing lever is in the act of breaking. This is the position in which the timer-distributor should be set, and a mark should be made on the base of the sleeve to correspond with a mark on the shaft, so that when the timer-distributor is removed, it may be replaced in the proper position. When the timer-distributor is secured in position, the battery timer and magneto interrupter should break their respective circuits at the same time.

Connections.

The connections of the timer-distributor must be made in accordance with the wiring diagram shown in Fig. 1. The positive terminal of the battery is to be grounded, and the negative terminal led to No. 5 of the stationary switch plate. Switch terminal No. 1 is then to be connected with the binding post located on the under side of the timer-distributor. The second binding post on the timer-distributor, which is located on the under side of the timer control arm, is to be grounded. Switch terminal No. 2 is to be connected to the grounding terminal of the magneto.

The cover of the timer-distributor may then be replaced, but a careful note should be made of the distributor terminal, with which the distributor brush is in contact. The distributor terminal should be connected to the proper spark plug of the cylinder with which the distributor of the magneto is in circuit. The remaining distributor contacts should be connected in accordance with the firing order of the engine, and will, of course, be identical with the connections of the magneto. Switch contact No. 4 is then to be connected to the central contact of the timer, this completing the connections.

Detection of Trouble.

If there is a failure of ignition, it is necessary to determine whether the fault is in the magneto or battery system, and this may be done by comparing the operation of the engine with the switch in "B" and in "M" positions.

If this shows the fault to be in the magneto, that instrument should be tested and examined.

In the following description of the location of faults in the battery system, it is taken for granted that the operation of the magneto is satisfactory.

1. **Missing in one Cylinder.** A failure of this character will almost invariably be due to a defective spark plug, but if the failure persists after a new spark plug has been inserted, the cables should be examined for a defect.

2. **Irregular Ignition in all Cylinders or complete failure of Ignition.** This condition may be due to a weak battery, the voltage of which has dropped below the required six volts.

If the battery shows the proper voltage, cables 1, 4, 5, 6, 7 and 8 should be examined to see that they are in good condition, and the connections properly made. The battery interrupter should also be examined for the free working of the lever, and to see that the points are clean and in good condition.

If the failure persists, the switch contacts should be inspected.

To determine the condition of the spark coil, cable No. 4 should be disconnected

from the distributor and its terminal brought to within one-third inch of the metal of the engine. On operating the press button a strong vibrator spark should appear, if the battery circuit-breaker is open; and if the battery circuit-breaker is closed, a single contact spark should be seen. If this is the case, it is evidence that the coil is in proper condition.

If no sparks appear, the fault is located in the spark coil, which should be returned to the makers or to one of their branches for examination.

3. **Motor will not start on the Pressing of the Button.** It should first be ascertained if the motor is in proper working condition, and if the cylinders contain mixture. To secure the latter condition, a few drops of gasoline may be injected into each cylinder through the priming cock. It should then be ascertained that the switch is in position "B" and that the timing control lever is in the full retard position.

If the motor will not start on the press button under these conditions, the switch should be left on position "B" and the motor cranked, the cylinders again being primed with gasoline.

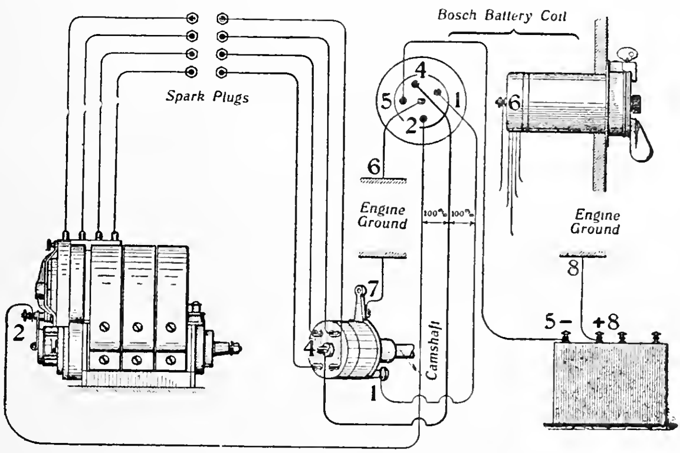


Fig. 1.

BOSCH VIBRATING DUPLEX IGNITION SYSTEM.

This system is composed of the magneto, vibrating coil, and switch. The arrangement is such that ignition may be had from battery or magneto as desired. The complete ignition system operates on one set of spark plugs.

With the exception of the D and DR types, practically any of the standard independent Bosch High Tension Magnetos employed on the automobile-type engines can be used, without alteration, in connection with the Bosch Vibrating Duplex System, merely by the addition of the coil, switch, and battery. See Fig. 2, 3, and 4.

In case of Bosch D and DR types, the necessary alterations to adapt these magnetos for use with the vibrating duplex system can be made at any Bosch Branch.

Care and Maintenance.

Coil. The only parts of the coil subject to wear are the platinum vibrator contacts, and, except for occasional adjustment of these contacts, the coil requires no attention. The adjustment for wear is effected by removing the coil cap, loosening the hexagon lock-nut, and slightly screwing in the slotted adjustable contact screw. This brings the platinum vibrator contacts in touch with each other, and compensates for whatever wear may have occurred. This adjustment need be made only once

or twice during the season, but when made, care should be taken to tighten the lock-nut firmly.

Perhaps once during the season the adjustable contact screw should be removed, and if the contact surface is uneven or in bad condition, it may be smoothed by means of a fine, flat jeweler's file.

When cranking an engine equipped with the Bosch vibrating duplex ignition system, the spark lever must always be fully retarded. The S 17 switch should be in the "battery" position, or where the S 12 switch is used the press button key should be in position.

Troubles, Cause, and Remedy.

Since the battery circuit operates in conjunction with the magneto, faults due to the magneto will also appear on the battery side. On engines which can be cranked at a speed sufficient to produce ignition from magneto direct, the magneto should always be tested independent of the other units of the vibrating duplex system, by disconnecting the low tension wire leading from the battery to the coil, or on Bosch Fly-wheel starter equipped engines, from the starting motor switch to the coil.

If the coil does not vibrate when the switch is in the battery position, and the engine fails to start when cranked, the difficulty may be due, first, to the battery voltage dropping so low that the vibrator does not operate; second, to chafing of the low tension wires between the battery and the coil, or between the starting motor switch and coil. Look at the cables and see that there are no broken or loose connections. Such an interruption in the battery circuit might be caused also by the vibrator contacts not being in touch with each other. See that the contacts are adjusted so as to just meet.

If the coil vibrates when the switch is in the battery position, but the engine fails to start when cranked, it should be determined first that the cylinders are receiving gas properly, and in the case of Bosch Fly-wheel Starter equipped engines, that the press button key of Switch S 12 is in position. Should these conditions be correct, the difficulty may be due to chafed wiring between the coil and the magneto, magneto interrupter contacts not opening, or finally, to the magneto grounding terminal being short-circuited. Any of these conditions will allow the battery current to escape to ground without passing through the magneto primary circuit, thus preventing the induction of high tension current into the magneto secondary circuit.

If the coil does not vibrate when the switch is in the battery position, but the engine starts when cranked, the difficulty will probably be found to be due to an interruption in the battery circuit. Under such a condition, the starting of the engine is due to its operating on the magneto direct, and the wiring for the battery circuit should carefully be gone over with a view of locating any possible loose connection or break. Should the engine start on the battery side of the system, but fail to operate on the magneto side, the difficulty will likely be found to be due to either magneto interrupter contacts not separating sufficiently, or to the spark plug gaps being too wide.

BOSCH DUAL IGNITION, "DU" AND "ZR" TYPE MAGNETOS

Connections.

The wiring diagram of the "DU4" Dual System is shown in Fig. 5. It will be noted that while the independent magneto requires but one switch wire in addition to the cables between the distributor and spark plugs, the Dual system requires four connections between the magneto and the switch. Two of these are high tension and consist of wire No. 3 by which the high tension current from the magneto is led to the switch contact, and wire No. 4 by which the high tension current from

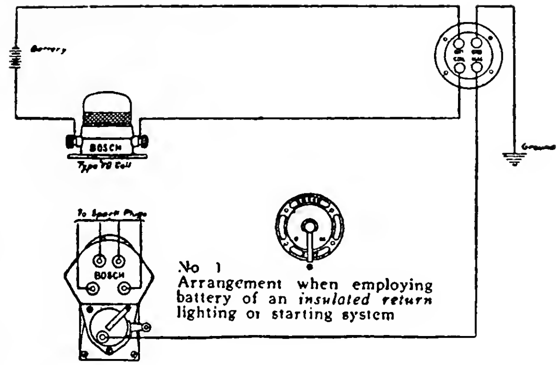


Fig. 2.

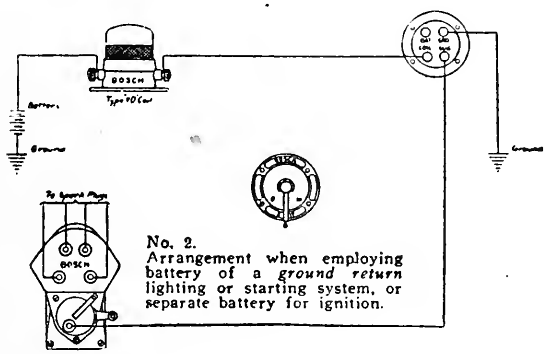


Fig. 3.

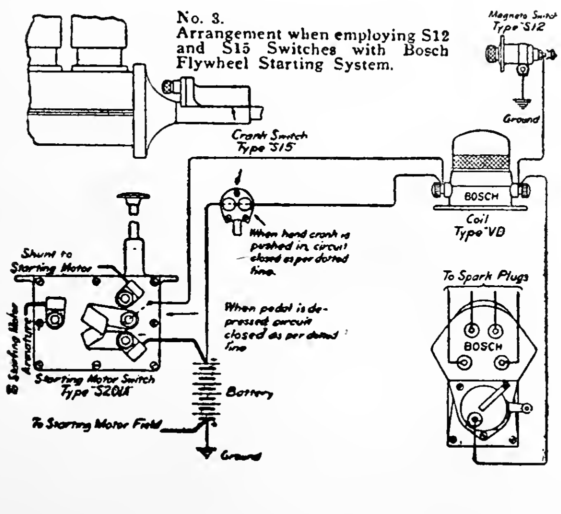


Fig. 4.

either magneto or coil goes to the distributor. Wire No. 1 is low tension and conducts battery current from primary winding of the coil to the battery interrupter. Low tension wire No. 2 is the grounding wire by which the primary current of the magneto is grounded, when the switch is thrown to the off, or to the battery position. Wire No. 5 leads from the negative terminal of the battery to the coil, and the positive terminal of the battery is grounded by wire No. 7. A second ground wire

The wiring diagram of the "ZR6" dual system is shown in Fig. 6. In the "DU" dual, magneto current is led from the collector ring connection to the coil and back to the distributor terminal that is located in the center of the distributor plate.

In the "ZR" dual magneto, this central distributor terminal is eliminated, and the current is led internally to the distributor from a connection on the shaft end of the magneto. To expose this terminal, the shaft end hood should be removed, which is done by withdrawing the two screws in the lower flange, and sliding the hood backward. The terminal will then be seen to be a vulcanite post, with a boss that projects through a hole in the hood. In the top of this post are two vertical holes, in the bottom of each of which is a screw. These screws are to be withdrawn. The ends of the high tension wires No. 3 and No. 4 leading to the coil should be cut off square, and after being led through the holes in the hood are to be pressed into the bottom of the holes in the boss. The pointed screws are then to be replaced in the vertical holes, and in being driven home, will pierce the cables, and make the required connections. It is essential to use a screw driver of the proper size, as a tool with too large a blade will crack the vulcanite. Great care must be taken to apply the screw driver to the screws vertically, in order to prevent breaking the vulcanite due to side pressure. After the connections are made the hood should be replaced. When the thumb-nuts on the distributor plate are screwed into position, the edges should press on the end of the cable insulation, thus expanding it and making a tight, moisture-proof fit in the recess of the circular boss.

Detection of Faults.

In the event of a failure of ignition, it should be determined whether the defect exists in both the battery and the magneto side of the system, or in either one of them. This may be determined by throwing the switch from one position to the other.

If there is a continual miss in one cylinder on the magneto as well as on the battery, the fault usually lies in the spark plug, which will be found to be fouled, broken, or to have too wide a gap; the gap should be from .018 to .020 inch, according to the characteristics of the engine.

If a failure is found in all the cylinders on the battery as well as on the magneto, the probable fault will be a short circuit due to a failure of insulation of the cables, to improper contact, or to the grounding of the terminals; the fault may also be due to a broken cable. High tension cables Nos. 3 and 4 should be examined.

Magneto Faults.

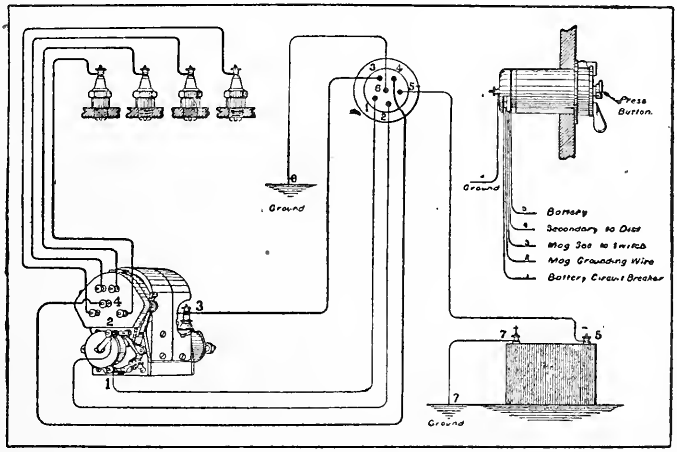
If the switch shows that the magneto is at fault, all the cables and terminals should be examined for improper connections. The coil and battery system may then be disconnected by removing the wires from terminals Nos. 3 and 4 of the magneto, and with a short piece of wire magneto terminal No. 3 may be connected directly with magneto terminal No. 4. This will conduct the high tension current induced in the magneto direct to the distributor. The grounding wire should then be disconnected from terminal No. 2 of the magneto. With this arrangement it should be possible to start the engine on the magneto, and it will be necessary to follow this plan should any accident happen to the coil.

To ascertain if the magneto is generating current, the grounding wire should be disconnected from terminal No. 2 on the magneto, and the high tension wire should be disconnected from terminal No. 3 on slip-ring brush holder. If the engine is then cranked briskly, a spark should appear at the safety spark gap that is located under the arch of the magnets on the dust cover, provided the magneto is in proper condition. The grounding wire should then be reconnected to terminal No. 2, and the engine cranked. If no spark appears at the safety spark gap, the trouble may be determined as a leakage of the primary magneto current to ground by chafed insulation, incorrect connections, or an injury to the switch parts.

Battery System Faults.

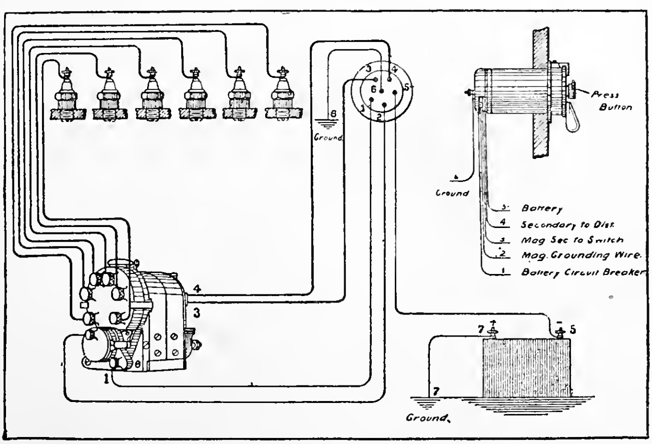
If the engine misses on the battery and runs correctly on the magneto, the fault will usually be found in the battery itself, the voltage having dropped too low. Should the battery show the proper voltage, the battery interrupter should be examined to observe whether the lever is moving freely and whether the platinum points are clean and properly adjusted.

Fig. 5.



—WIRING DIAGRAM OF THE DU4' DUAL SYSTEM

Fig. 6.



WIRING DIAGRAM OF THE "ZR6" DUAL SYSTEM

The coil may be tested by disconnecting wire No. 4 from the magneto and throwing the switch to the battery position, operating the press button with terminal No. 4 four and one-eighth inches from the metal of the engine. If the coil is in good condition, a brilliant spark should be observed. If the spark does not appear, the test should be repeated with wire No. 3 disconnected. If the fault persists, the coil body may be removed from the housing by withdrawing the holding screw that is located close to the supporting flange; the screw should then be unlocked and the end plate given a quarter revolution. This will release the bayonet lock and the coil body may then be withdrawn to permit the inspection of the switch contacts both of the coil and of the stationary switch plate. It may be that the spring contacts are bent or otherwise in bad condition. The withdrawing of the coil body and its handling should be performed with extreme care. No work should be done on the coil in the way of withdrawing screws, etc., and if the inspection does not disclose the fault, the coil should be returned to its housing and the whole returned to the Bosch Magneto Company, or its nearest official representative.

BOSCH DUPLEX IGNITION SYSTEM.

The following points must be borne in mind in mounting the ignition system and in making the connections:

The timing range of the duplex magneto, the speed at which they must be driven with relation to the engine crank shaft, the manner of drive, also the procedure in connecting the high tension cables from the magneto to the spark plugs in the cylinders, are all exactly the same as with corresponding independent Bosch types.

The battery connections and the connections between the battery, coil, and magneto, must be in strict accordance with the wiring diagrams. A six-volt storage battery is recommended. With the exception of the cables to the spark plugs, all connections are low tension, and the wiring should be made accordingly.

Great care must be taken to prevent the possibility of the battery becoming grounded, either through improperly protected terminals, faulty insulation, or short circuiting among dry cells, when such are used, or their grounding to the metal battery box they are in.

Setting the Magneto.

The magneto is to be secured to the base provided for it, with the driving gear or coupling loose on the armature shaft. The engine should then be cranked until No. 1 piston is at top dead center of the compression stroke, and should be maintained thus until completion of the installation.

The timing arm attached to the interrupter housing is to be placed in full retard position, which is accomplished by moving it as far as possible in the direction in which the armature will be driven. The cover of the interrupter housing is to be removed to permit inspection of the interrupter, and the armature is to be rotated in the direction in which it will be driven, until it is seen that the magneto interrupter screws are in act of separating. The high tension wiring to the plugs should be connected in the usual way.

The armature is to be held firmly in that position while the driving gear or coupling is set tightly on the armature shaft. The cover of the interrupter housing is then to be returned to position and the setting is complete.

The setting above described will render it possible to operate the engine, but the engine characteristics may make it possible that a slightly different setting will give somewhat better results. It is frequently the case that with the interrupter breaking in full retard position when the crank shaft is about five degrees over the top dead center of the compression stroke, more satisfactory results will be obtained.

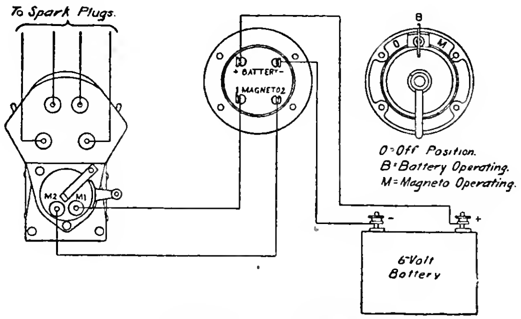
The changes made in determining the best setting should be very slight, a

change of more than a few degrees may have a marked effect on engine operation. When specific instructions for magneto setting are given by engine manufacturers, it is recommended that they be followed in preference to those given here.

The instructions for care and maintenance of duplex magnetos, as well as for locating and remedying troubles, are the same as for other Bosch systems as described in this book. See Figs. 7, 8, and 9.

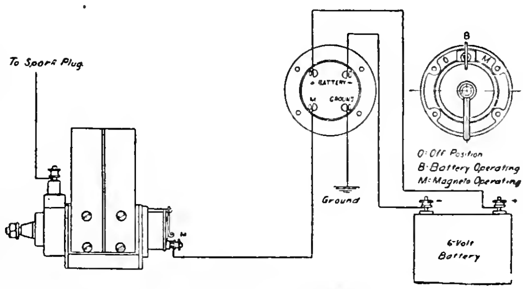
Wiring Diagrams for the Bosch Duplex Ignition System

Fig. 7.



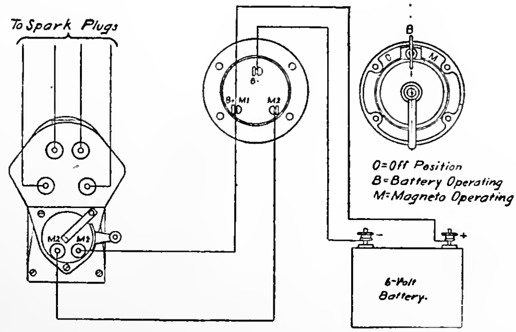
1 For Types "La2" and "Ma" Coils

Fig. 8.



2 For Types "La1" and "Ma1" Coils

Fig. 9.



3. For Type "M" Coil

BOSCH TYPE "K4" DUAL SYSTEM, MAGNETIC PLUG IGNITION.

Magnetos of the "K" type operating with magnetic plugs for the production of a low tension ignition spark are constructed in Dual form, the principle of operation being similar to that employed in the high tension dual system.

With the dual system it is possible to secure ignition either by magneto, or by battery and coil, with the use of but one set of plugs. These plugs are connected to the magneto distributor in the usual manner, but the magneto connections are so arranged that the magneto current does not flow direct from the armature to the distributor, but passes first to a switch. Through the operation of this switch, either the magneto current or the battery current may be passed to the plugs. See Fig. 10.

In addition to the magneto interrupter, the magneto is provided with a separate interrupter for the battery circuit, one being located immediately below the other.

The magneto interrupter is of the usual rotating form, whereas the battery interrupter has a stationary lever operated by a rotating steel cam that forms part of the magneto interrupter disc. The two interrupters normally operate synchronously, but if engine conditions require it, the battery interrupter may be set to operate somewhat later than the magneto interrupter.

The coil used on this system is similar in outward appearances to the Bosch high tension dual coil. Its windings are low tension, however, and it is not provided with a vibrator of the usual form. The button for self-starting, located in the center of the end plate, makes and breaks the battery circuit by being depressed and released, and single contact low-tension sparks are produced.

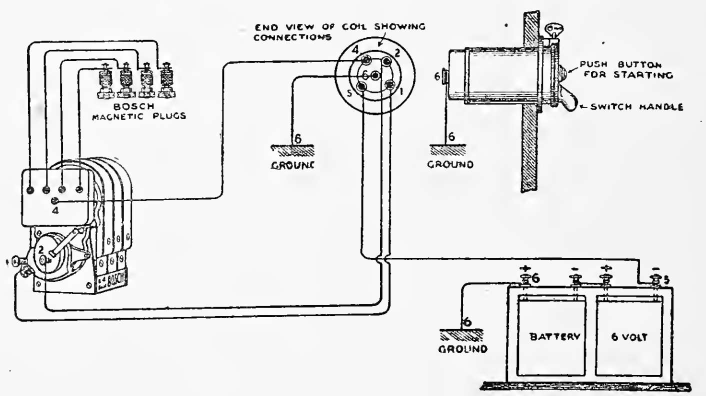


Fig. 10.

A six-volt battery should be employed with this system, and this should preferably be a storage battery. If dry cells are to be used, ten should be connected in multiple series. The cells should be divided into two groups of five cells each, the cells of each group being connected in series. This will leave a positive and a negative terminal of each set free. The positive terminals should be connected together and grounded, while the negative terminals should be connected together and led to the terminal No. 5 on the switch.

The system must be wired in accordance with the diagram, and in making the connections it is most advisable to use regular Bosch cables provided with Bosch loop terminals. Many terminals of other types will tend to permit short-circuiting, particularly in the case of the coil connections.

Difficulties in the battery side of the system may invariably be traced to de-

fective wiring, water or oil-soaked insulation of the cables, or a cross connection between two cables or terminals

Should this system operate on the magneto, but not on the battery, the battery should be tested for voltage, and examinations should be made for loose connections. If the battery is in good condition and the connections are in correct order, the battery interrupter should be inspected. The interrupter lever should move freely on its pivot, and its platinum contacts should be free from oil or grit. If it is found that the lever does not move free on its pivot, it may be removed, and the fiber bushing should be cleaned of any dirt or gummed oil that may have lodged in it. It should then be lubricated with a small drop of sperm oil and replaced. If it then does not move freely, the bushing should be lightly reamed out. If the platinum points are corroded, they should be trued by means of a very flat file, but this should only be done in case of necessity.

The magneto bearings should be lubricated with twelve drops of good, light oil every two weeks, and great care should be taken to prevent the entrance of excess lubricating oil in the interrupter parts. The interrupter bearings are self-lubricating and do not require oiling. The magneto should be wiped off occasionally and kept free from dust and oil.

Should the oil become injured to such an extent that it is impossible to operate either on the battery or on the magneto, cables No. 2 and No. 4 should be disconnected from the switch plate, and one of these cables be connected directly with the other. This will convert the dual magneto to the independent form, and it should be then possible to start the engine directly on the magneto, and to operate on it.

To cut out ignition with the Magneto arranged in the manner described, a connection to ground should be made with either terminal No. 2 or No. 4.

EISEMANN HIGH TENSION IGNITION SYSTEM TYPE E. M.

This dual system consists of a high tension magneto and a combined transformer coil and switch. The transformer proper, being used only in connection with the battery, and the switch used in common by both battery and magneto systems.

The magneto is practically the same as the single ignition instrument, with the exception of a few changes and additions. To insure reliability, the vulnerable parts of each system are distinctly separate from those of the other.

For instance, separate windings and contact breakers are used on each system. On the other hand, parts that are not subject to accident, or rapid wear, are used in common, so as to avoid unnecessary duplication.

The wiring diagram of this system is shown in Fig. 11.

EISEMANN MAGNETO WITH AUTOMATIC SPARK CONTROL. TYPES ERa, EDa, and Eua.

The Automatic Spark Control Magneto. See Fig. 12.

It is of the same construction as the standard high tension instrument, with the addition of the automatic mechanism. The automatic advance is accomplished by the action of centrifugal force on a pair of weights attached at one end to a sleeve, through which runs the shaft of the magneto, and hinged at the other end of the armature. Along the armature shaft run two helicoidal ridges which engage with similarly shaped splines in the sleeve. When the armature is rotated, the weights begin to spread and exert a longitudinal pull on the sleeve, which in turn changes the position of the armature with reference to the pole pieces. In this way the movement of greatest induction is advanced or retarded, and with it the break of the primary circuit, for the segment (or cams) which lift the circuit breaker, and cause the break in the primary circuit, are fixed in the correct

Wiring Diagram—E M Dual 4 cyl. and D C Coil (Same Wiring for D C R Coil)

(In 6 cylinder type there are essentially two extra cables from distributor to plugs.)

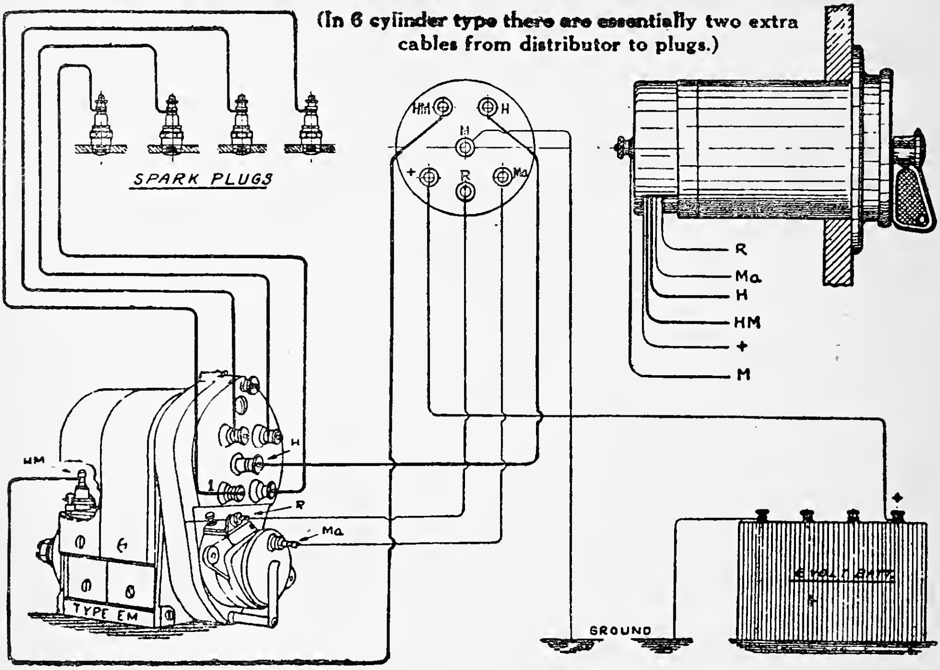


Fig. 11.

position and thus the break occurs only at the moment when the current in the winding is the strongest.

Maintenance.

Oiling. A few drops of oil injected into the reservoirs for that purpose is sufficient lubrication for about 1,000 miles. In the single ignition instrument, the distributor shaft is fitted with a wick oiler and this should be cleaned every six months or so. This wick can be reached by removing the wick screw. To insure correct ignition, all wiring connections must be kept tight, and the cable insulations must be protected from oil or chafing. The platinum points of the circuit breaker must be kept clean and correctly adjusted. They should open about 1-64 inch.

Safety Spark Gaps.

If the plug cables are fractured or broken away from the plugs, or the electrode (spark gap) distance is too great, the high tension current discharges itself at the safety spark gap, which is fixed on the armature case cover. The spark is, of course, intermittent and it is a simple and necessary provision from otherwise dangerous secondary tensions, to the insulations of the armature, and the other current conducting parts. Never alter the safety gap, and see that the long cigar-shaped high tension conductor is always in contact with the collector brush holder and the top of the safety gas cover. If the spark jumps in the safety gap, you may be sure that there is something wrong with the wiring or the spark plugs.

Wiring

The wiring diagram as shown in Fig. 12. The wires shown by heavy lines are high tension, and thin lines are low tension.

Locating Troubles and Remedying Them.

If the motor misfires or refuses to start, an examination must first be made, to see if the fault lies with the magneto or the plugs. If only one cylinder refuses to fire, the fault will probably be found in the corresponding plug. We would suggest in this event a change of plugs.

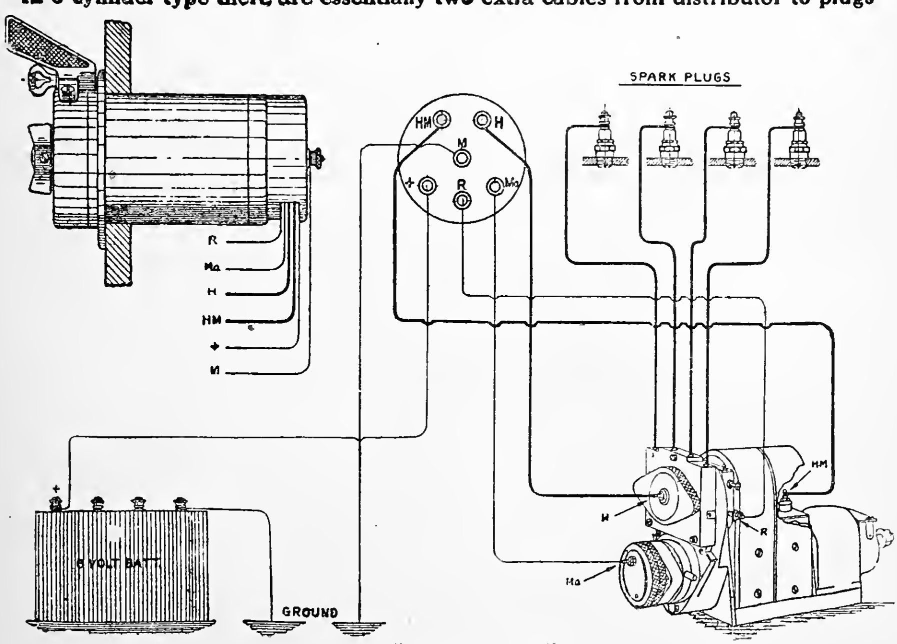
Spark Plugs.

(1) Plug points carbonized; (2) plug points too wide apart; (3) plug faulty. Remedy—(1) Clean with gasoline; (2) reduce gap between points to 1-64 inch; (3) replace by new one. By reason of the very powerful spark at the ignition electrodes of the plug, sometimes little metal beads are formed on one of them which will be short-circuit in time. This can be removed by filing away the beads of metal.

Platinum Contacts Burned or Soiled.

Remedy—Clean with gasoline until the contact surface appears quite white, or use a fine flat file, but very carefully, so that the surfaces remain square to each other. The gap at the contact point should not amount to more than 1-64 of an inch, and as the contacts wear away in time, they must be regulated now and then by giving screw a forward turn or eventually by renewing. By loosening screw the whole interrupting mechanism may be taken out, so that the replacement of the platinum contacts, without removing the apparatus, can be easily done at any time. The fixing screw of the make-and-break is held fast by a lock spring so that it is impossible for this screw to loosen. When it is desired to remove the screw, the lock spring must first be removed by turning it over the head of the screw. This spring must be replaced in the original position after having fixed the make-and-break to the armature by means of the screw.

In 6 cylinder type there are essentially two extra cables from distributor to plugs



Wiring Diagram Coil DCR

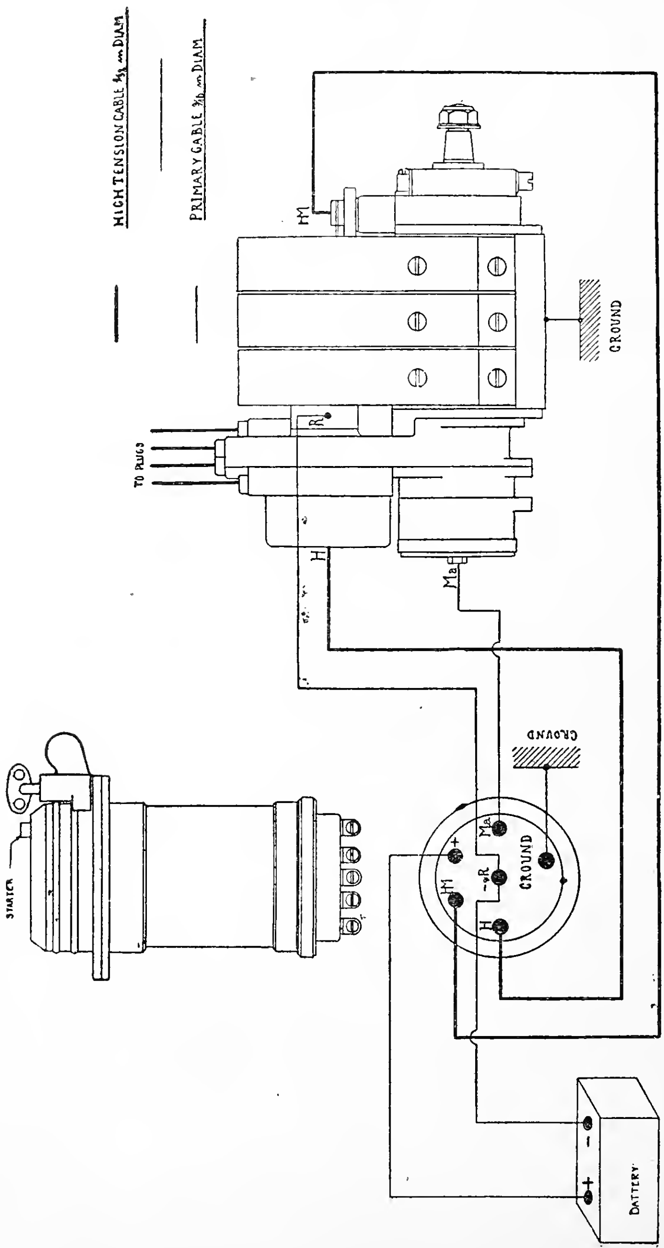
Fig. 12.

Distributor Plate Soiled.

Remedy—Take out distributor arm and clean all the contacts of the distributor plate with gasoline.

Irregular Firing.

Remedy—This can be caused only by the improper working of the contact breaker. Remove the cover by pressing back the two springs holding it in place.



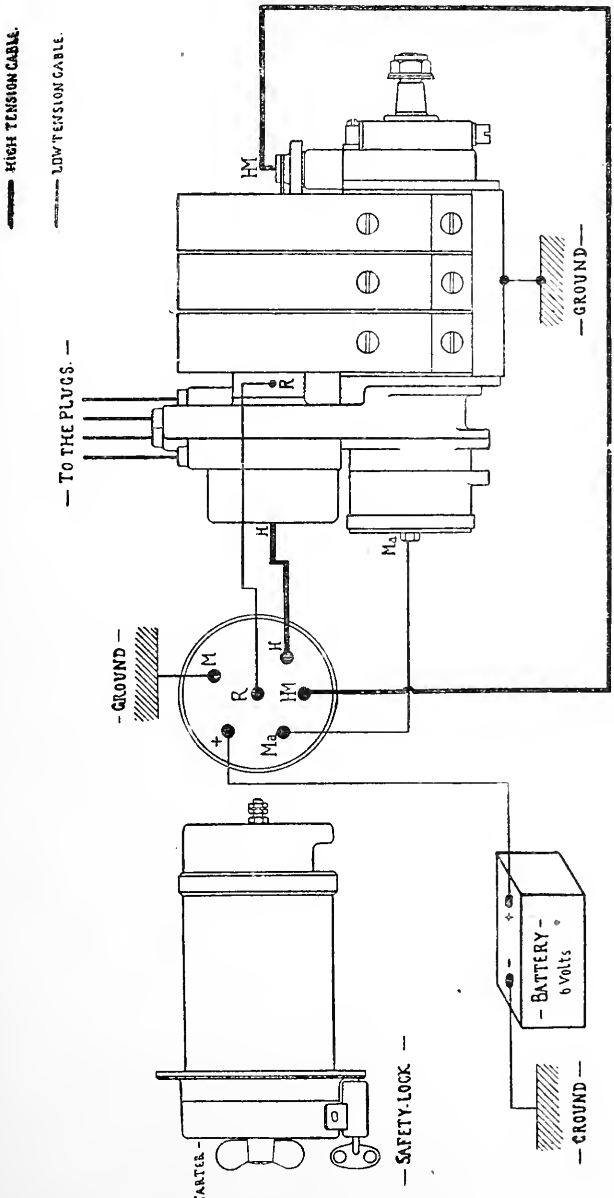
Wiring Diagram—DT Coil

Fig. 13.

See that the make-and-break mechanism is well in place by tightening screw and also that both platinum contacts are rigid. If the contact lever is jammed, clean the lever axle as well as the lever by lightly rubbing with emery paper or cloth and slightly oil the axle.

Cables.

(a) Loosened; (b) broken; (3) wrongly connected. Remedy—(a) Tighten; (b) replace; (c) consult wiring diagram.



Wiring Diagram D2U—DCR Coils

NOTE —This cut shows the D2U coil The DCR connections are exactly the same, but the terminals on the bottom of the coil, according to the symbols, occupy different positions on the plate Wire according to the symbols.

Fig. 14.

Carbon Brushes Soiled or Worn.

Remedy—Clean with gasoline or change carbon brushes. If the examination so far has not led to detecting the defect and the motor will not start, then the carburetion may be faulty.

Magnets.

A re-magnetization of the magnets will only be necessary if these have been taken away from the apparatus and allowed to remain a long time without both ends of the magnets being connected with a piece of soft iron. The same thing occurs if the armature is taken out of the pole pieces without a conducting rod of iron being laid across both poles. This piece must remain on the poles until the armature is again placed between the pole pieces. Often the magnets, after being taken down, are put back in the wrong position, and in this way the magnetic power is neutralized. To prevent this mistake, all magnets are now marked, the north pole being designated by the letter "N" stamped in the magnet. When replacing magnets, care should be taken to place the same poles on the same side.

EISEMANN MAGNETO, TYPES EA, EU, AND ED, WITH MANUAL SPARK CONTROL.

The magnetos used in this dual system are, with a few additions, about the same as the regular single instrument. The types EA, EU, and ED are identical in design and construction, the only difference being in size.

The coils which are used in connection with these magnetos for dual ignition are known as types D2U, DCR, and DT. The D2U and DCR are non-vibrating and the DT is equipped with a vibrator. The D2U and DCR coils have mechanical vibrators, actuated by means of ratchets to facilitate starting on compression. The DT coil has an electrical vibrator, which is set in motion when the

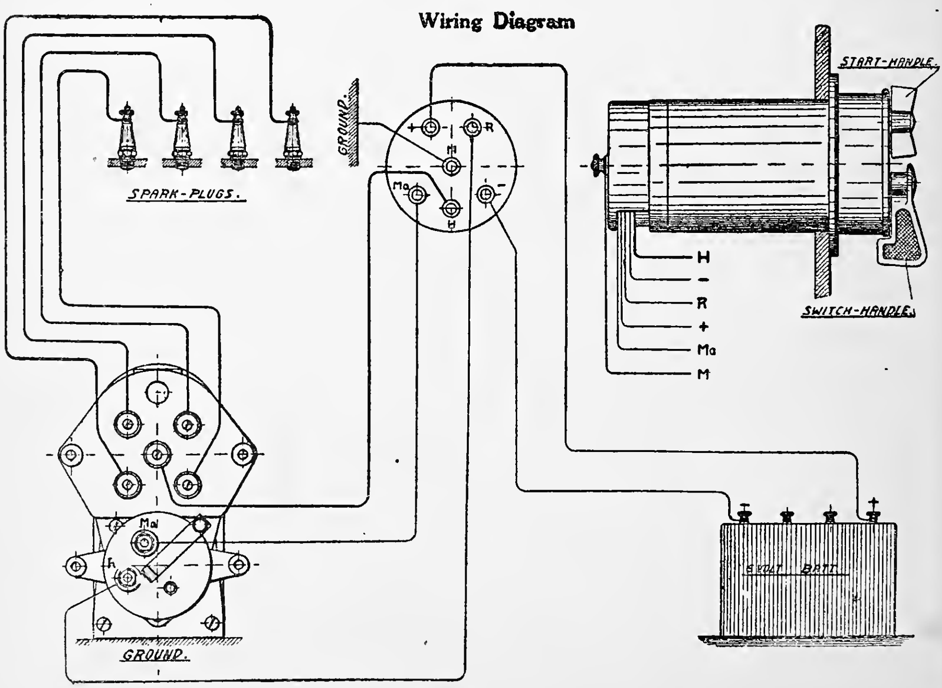


Fig. 15.

switch is thrown to the "Bat" position, providing the battery breaker mechanism contacts are closed. If they happen to be open, which depends upon the position of the motor, by pressing the button on the coil-cover, the proper connection is established and the vibrator is set in motion. These coils embody the necessary switches for both the magneto and coil.

The wiring diagram of this system when using DT coil is shown in Fig. 13. The D2U or DCR coil used in connection with this system is shown in Fig. 14. This cut shows the use of the D2U coil. The DCR connections are exactly the same, but the terminals on the bottom of the coil, according to the symbols, occupy different positions on the plate. Be sure to always wire according to symbols.

EISEMANN HIGH TENSION DUAL SYSTEM MAGNETO (TYPE E. B.) AND TRANSFORMER COIL (TYPE B. D.) See Fig. 15.

This recent product of the Eisemann Magneto Co. consists of a magneto generating an alternating primary current only and a combined transformer coil and switch in which this primary is transformed into high tension current.

The care and maintenance of this system is about the same as with all other Eisemann systems. The setting of the platinum breaker points and the spark plug gaps are the same as with standard models. The wiring of this system is shown in Fig. 15.

MEA MAGNETOS.

The Mea High Tension Magneto has bell-shaped magnets placed horizontally and in the same axis with the armature. This at once makes possible the simultaneous advance and retard of magnets and breaker, instead of the advance and retard of the breaker alone. See Figs. 16, 17, and 18.

Timing of the Magneto.

The greatly varying characteristics of different motors prevent the giving of a general rule regarding the best timing of the Mea Magneto. It is desirable that the magneto be timed so that it is possible to give the motor a spark as far advanced as it can stand at a maximum speed, as only in this manner the maximum output of the motor will be obtained.

The Mea range of advance and retard is great. It is sufficiently great enough to insure a retarded spark late enough for cranking and low speed running, no matter how much advance is decided upon. If the motor characteristics with regard to possible advance are unknown it is advisable to try to determine them and to proceed as follows:

Unless the timing of the magneto can easily be changed by advancing or retarding the gear driving the magneto, the coupling should not be keyed to the tapered shaft before the magneto is first placed on the motor, but it should be clamped on so that the timing may still be modified somewhat if found desirable.

Place the magneto in the position of its maximum advance by turning the magneto housing or timing lever in the direction opposite to that of armature rotation. Remove cover from breaker box and turn armature shaft in direction of rotation until No. 1 appears in the indicator on front plate of magneto and until contact breaker begins to open. Turn the motor until the piston of cylinder No. 1 is from ⅝-inch to ⅞-inch in advance of dead center. After magneto and motor has thus been set, effect a positive connection between the two.

Connect contact hole No. 1 of distributor to No. 1 engine cylinder by means of the cable having one ring on its contact plug. In connecting the others, be guided by the numbers on the distributor and by the succession of firing strokes of the different cylinders, using cables with rings corresponding in number to the numbers on the distributor.

The motor should now be started with the spark fully retarded, and by increasing the speed gradually it can readily be determined if the motor can stand all the advance which the magneto with its present setting can furnish, or if this advance might be further increased. After it has been assured that the best timing has been obtained the coupling should be keyed to the magneto shaft.

The resetting of the Mea magneto after it has been removed from a motor for cleaning and inspection purposes is extremely simple. Before removing the magneto, turn the motor or move the timing lever until one of the numbers appear in the indicator. Then remove the magneto by opening up the base bearings, and leave the motor undisturbed while magneto is out of its base.

In replacing the magneto, all that is necessary is to see to it that the same number as before is appearing in the indicator. The replacing of the cables can easily be done according to the number of rings on the hard rubber sleeves.

ATTENTION. Remove magneto from the base when bolting the latter to frame, and see that the bolts do not project above inside surface of base, as otherwise the bolts may injure the magneto housing.

In tightening the nut at front end of armature shaft, hold the armature on the coupling and do not try to prevent it from turning by holding it on the breaker; the latter is not designed for this service. Be careful to have the low tension wire well fastened at the terminal, so that no strands will touch uninsulated portion of the breaker box.

See that the spark plug gaps are set about 1-64 inch apart. The distance should not be greater than the thickness of the thin gauge attached to the small magneto wrench, which is also used for adjusting the low tension breaker.

Give the magneto a few drops of good oil every two weeks, but do not flood it with oil. Do not oil the breaker. Never remove the top cover supporting the high tension carbon while the magneto is running. This cover contains the safety spark gap, and if operating with the same removed, the armature winding is apt to be injured.

Locating Faults in the Ignition System.

Faulty Spark Plugs.

They are the most common cause of misfires, and in case of trouble they should therefore be inspected first. If the points are covered with soot or oil, the plug should be cleaned with gasoline.

If the points show beads which short-circuit the plug, they should be removed and the normal distance between points re-established. The latter should also be done if on account of melting away or for some other reason the distance between points has become excessive. This distance should be 1-64 inch, just sufficient to allow the gauge attached to the small magneto wrench to pass.

Frequently also the insulation of the plug is broken down, in which case a new plug is required.

Faulty Cables.

Noticeable by irregular sparking at cylinder end of cable with satisfactory sparking at magneto end of same, when spark tests at both ends are made.

To eliminate any effect of faulty spark plugs, test for spark between cable and cylinder body with magneto terminal of cable connected to magneto, and between cable and distributor contact of magneto with cylinder end of cable connected to cylinder body.

Grounding of Low Tension Wire.

Make sure that the low tension wire does not ground on the cover of the breaker box.

Defective Magneto.

The magneto should not be considered at fault unless spark tests between distributor contacts and magneto housing show irregular firing.

If the magneto is proven defective, the trouble will usually be located in the breaker. The platinum contacts burn off in time and readjustment becomes necessary, although this should be the case only at very long intervals. The adjustment of the breaker contact points when fully open is about 1-64 inch or slightly more. The small gauge attached to the magneto wrench may be used for checking this adjustment. The small lock nut of the contact screw must be tightened securely after each re-adjustment of the contacts.

In addition any oil or dirt reaching the contact points will in time form a fine film which prevents perfect short-circuit of the low tension winding. If the con-

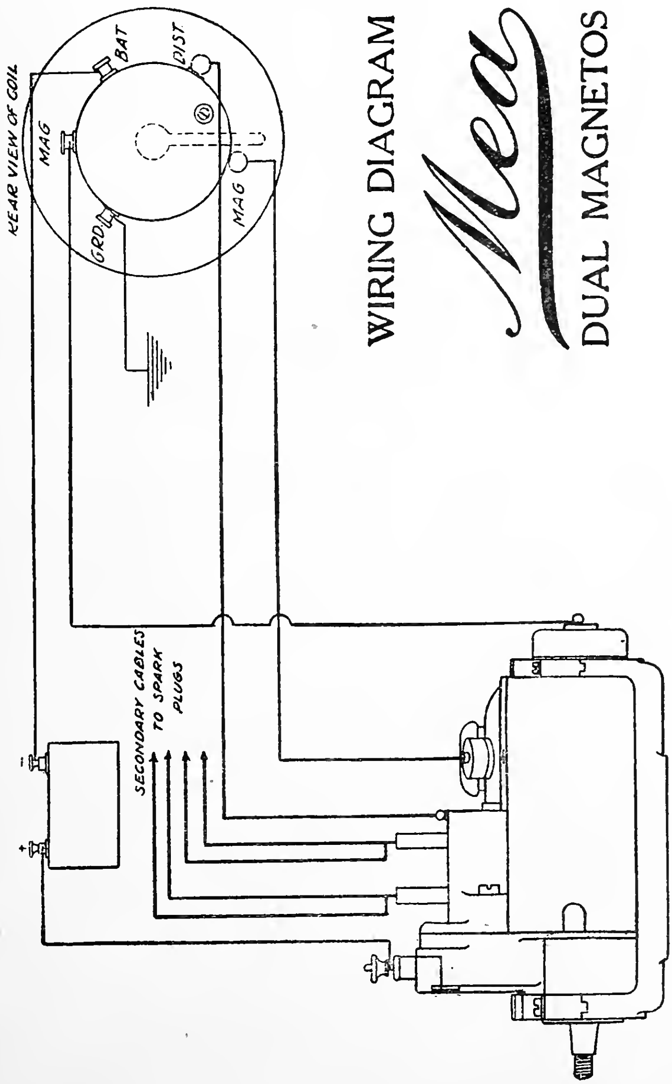


Fig. 16.

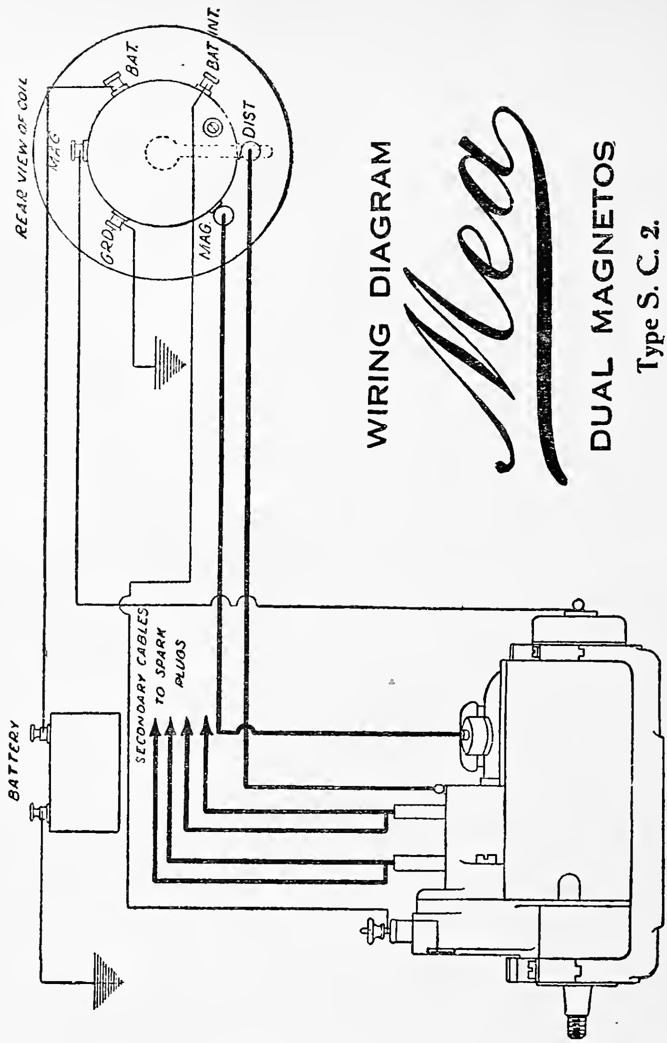


Fig. 17.

dition of these points is very bad, or if a complete inspection of the breaker is desired, the latter should be removed from the breaker box. This can carefully be done by loosening the long center screw holding the breaker to the armature, and screwing it into the small tapped hole provided in the breaker, so that it may be used as a handle in lifting the breaker out. The cleaning of the points should best be done with fine crocus paper, or if necessary with a very fine file, after which a piece of very fine cloth should be passed through between the points so as to remove all sand or filings. Special care must be taken not to round off the edges of the contact points; the satisfactory operation of a magneto depends largely upon the perfect contact at this point, and the whole surface of the contacts should therefore touch.

In replacing the breaker the small pin at its back must be introduced into the slot provided for it in the armature shaft and care must be taken not to tighten the center screw until the pin is in its proper place.

Another cause of a failure of a magneto to work properly may be a break-

down of the porcelain cover of the safety spark gap. This is usually a result of the porcelain injury and necessitates a replacing of the cover. It can readily be detected by trying the magneto with the spark gap cap removed, but as previously mentioned, the magneto should not be operated in this manner except with special care, i. e., at very low speed and with all cables connected so that no open circuit can occur.

An occasional missing may be caused by an excessive deposit of carbon in the inside of the distributor. This can easily be removed after loosening the two screws holding the distributor to the housing.

It should be stated emphatically that as a rule it will prove best to leave the magneto alone and not to try to improve it. If it furnishes a spark regularly it is doing its duty, and if, notwithstanding this, the motor does not work satisfactorily, the cause should be looked for at some other point of the equipment.

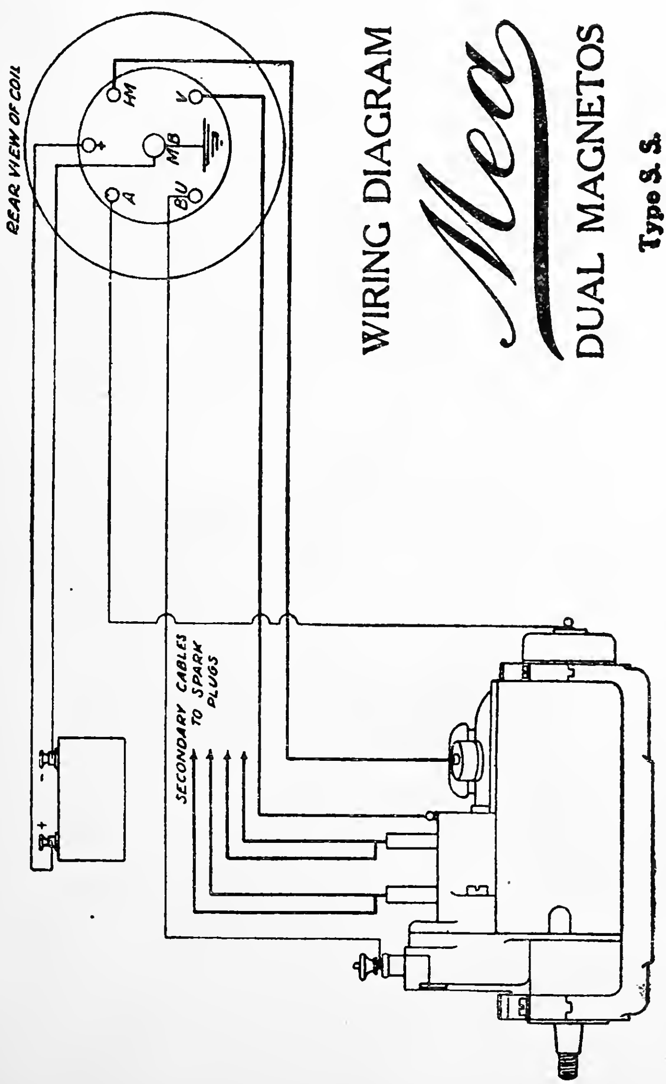


Fig. 18.

Assembling of Magneto.

For the information of the magneto expert only, and not in order to encourage investigations with regard to the inside of a magneto, the following points are mentioned:

For the satisfactory operation of a magneto, it is essential to have the breaker open at the proper relative position between armature and field. The output of the Mea is greatest if the spark occurs after the armature has passed through the neutral position and at the moment when the distance between the edge of the armature pole piece and that of the field is about 1-16-inch.

In assembling instruments with distributors the proper relation of the armature and distributor gears is important, as at the moment of firing the distributor carbon must be on one of the contacts. To assist in assembling, three holes are drilled into the end shield, the distributor gear and the end plate of the armature, in such a manner that if the three parts in question are assembled with the three holes in line, the relation between armature and distributor positions is correct. All that will be necessary, therefore, will be to introduce a pin into the hole at the end shield and to assemble.

REMY MAGNETOS RD TYPES.

While the RD type is not reversible, it can be furnished to run in either direction of rotation, but the adjustment for direction of rotation is made at the factory and cannot be changed. Remy magnetos are made in many different types, all of which are what is known as low tension magnetos.

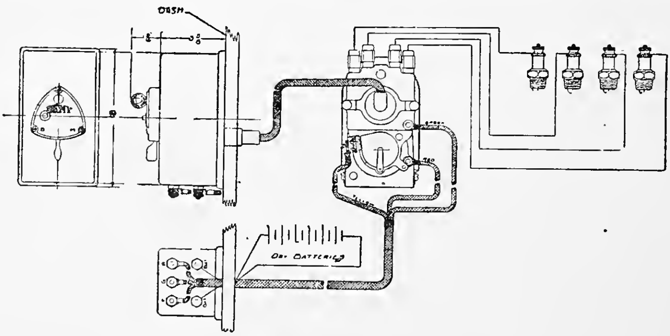
Attaching Magneto and Coil.

The magneto must not be set on iron or steel bracket or sub-base. Aluminum or brass should be used. Fasten coil by screw holes provided only. Screws must not be put in coil or coil box, even though the screws do not reach through the wood or fiber. When tube oil is used, the holder must be made so it does not entirely circle the coil.

The magneto must be wired strictly in accordance with the wiring diagram as shown in Fig. 19. Each of the three oilers of the magneto should be given a few drops of oil about every thousand miles. The cam is lubricated by means of a felt wick. This wick should be inspected often enough to keep it from running dry. It should be well saturated with oil, by means of a squirt can, whenever it appears to be getting dry.

Timing Magneto With Motor.

This magneto is to be timed to the motor by the break of the contact points. When the piston is on exact dead firing center, cam house must be in full retard



Type RD—Four-Cylinder Wiring Plan

Fig. 19.

position, and the platinum points must just be separating. The high tension cable from this cylinder, which is on exact dead firing center, should then be connected to the distributor terminal, corresponding to which the distributor segment is opposite. The remaining distributor terminals should be connected up in the proper firing order of the motor.

Spark Plug Points.

Different motors require different plug gaps. About .025 or .030 inch between the sparking points is best for most motors. If motor misses fire when running idle or pulling light, plug gaps should be made longer. If motor misses when pulling heavy, particularly at low speed, plug gaps should be made shorter.

Magneto Adjustment.

This magneto has but one adjustment, that of the contact screw. The adjustment should be made so that the maximum break of the platinum points is between .025 and .030 inch.

REMY TYPE RL MAGNETO WITH LE COIL OR LC COIL AND D OR H SWITCH.

See Figs. 20, 21, and 22.

Rotation.

These magnetos are set to run in one direction only. When ordering, it is necessary to specify whether the magneto is to run clockwise or counter-clockwise, the magneto being viewed from the driving end.

Installation.

It is absolutely essential, to obtain the best results, that the magneto be mounted on either an aluminum or brass bracket, or base. Magneto must be securely fastened to the base by cap screws or bolts, using the holes which are provided for this purpose, or else fastening same with a strap, in which case dowels are used in the magneto base instead of bolts or cap screws. Do not, under any conditions, drill or tap the magneto base.

Drive.

The magneto is to be positively driven, preferably by Oldham coupling, securely fastened to the shaft by Woodruff key and locked by nut. Do not leave the key out of the shaft, because the coupling is liable to shift, and this will throw the magneto out of time.

Timing Magneto.

Turn the engine over by hand until No. 1 piston reaches top dead center on compression stroke. Press in on the timing button at the top of the distributor and turn the magneto shaft until the plunger of the timing button is felt to drop into the recess of the distributor gear. With the magneto in this position, make the necessary connections to the motor. Pay no attention to the circuit breaker when coupling or setting gears, as the breaker is automatically brought into the correct position, and the distributor segment is in contact with No. 1 terminal. This No. 1 terminal is plainly marked on the distributor.

Spark Plug Connections.

The high tension cable from distributor terminal No. 1 is to be connected to

No. 1 cylinder of the engine. The remaining distributor terminals are to be connected up in the firing order of the engine.

Wiring Coil to Magneto.

Red wire goes to ground binding post in timer end bearing. Yellow wire goes to contact screw post on circuit breaker. Green wire goes to insulated screw post on timer end bearing.

Coil Connections.

The three colored wires of the primary cable must be connected to the terminals of the coiled marked Y (yellow), R (red), and G (green).

Connecting Battery to Coil.

Connect the two battery wires to the coil. Use either 6 volt storage battery, or five dry cells connected in series. If the other electrical apparatus on the car requires a ground connection, the grounded side of the battery should be connected to the coil battery terminal marked "R" on the LE coil or H switch, or to the red wire of the two battery wires projecting from the type D switch. Be sure to make good tight connections to all terminals.

Oiling.

Two oilers are provided, one at the rear of the magneto and the other just back of the top of the distributor. Give each of these three or four drops of good oil for each one thousand miles. Be careful not to flood the magneto with oil.

Magneto Connections.

The control arm is furnished on either side of the cam house as convenience demands, but in every case the yellow wire must be connected to the terminal of the platinum pointed contact screw. The green and red wires must be connected to the G and R screws respectively, which are located on the timer end bearing.

Spark Plugs.

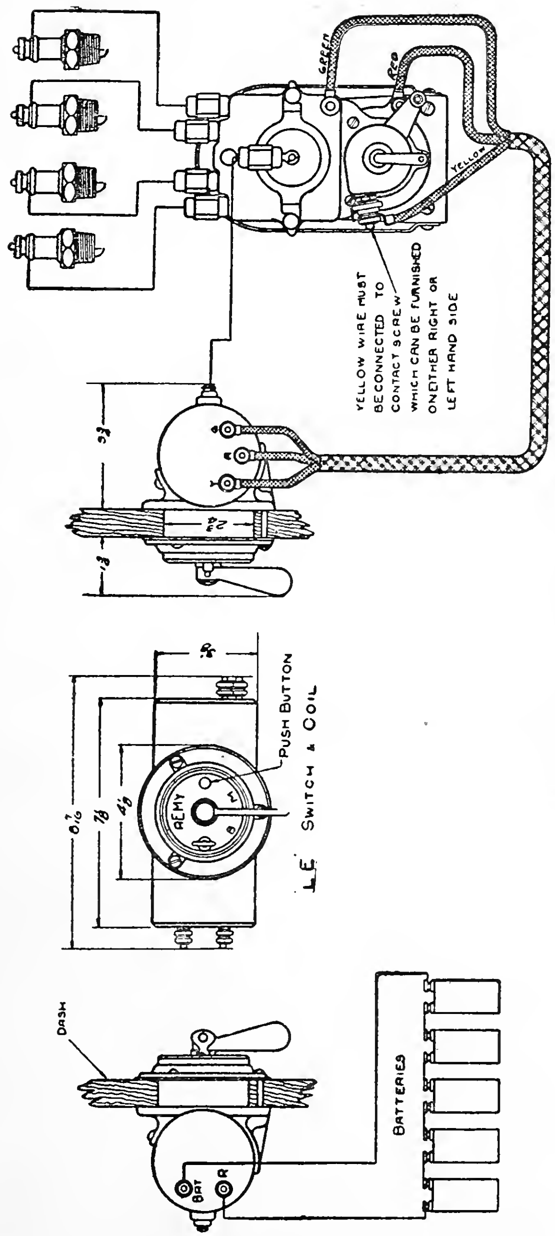
The gaps between the points should be between .020 and .025 inch. If the motor misses when running idle or pulling light, the plug gaps should be made longer. If motor misses when pulling heavy, particularly at low speeds, the gap should be made shorter.

Circuit Breaker, Platinum Contact Points.

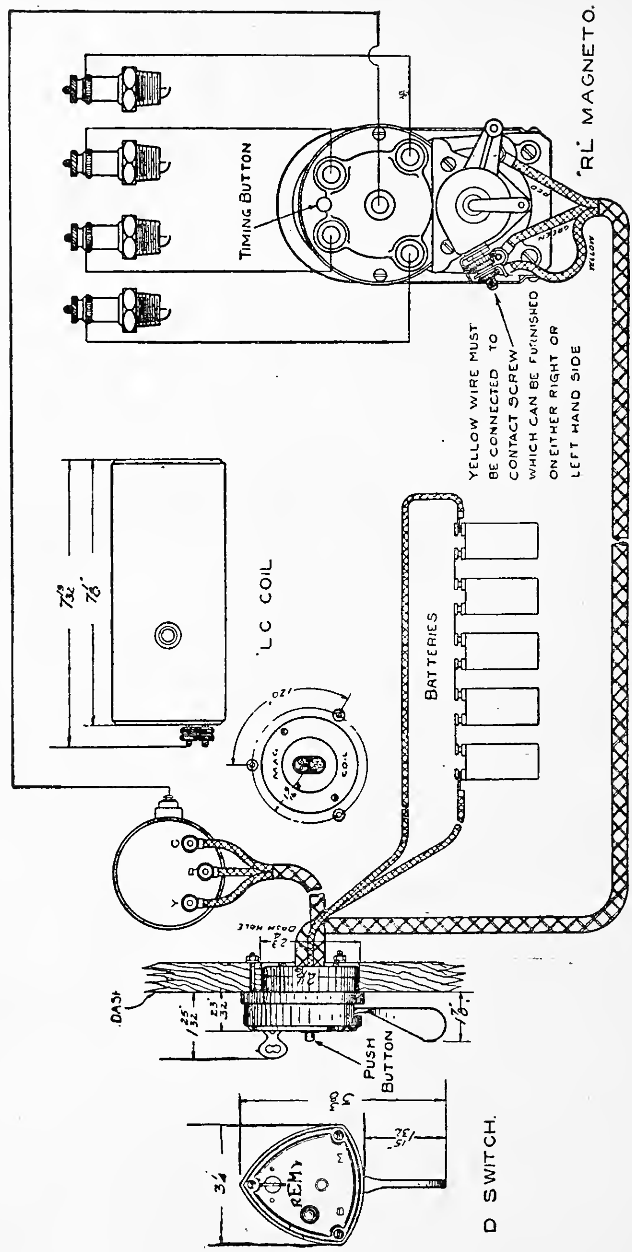
These points may be inspected by removing the cam house lid, or the cam house may be entirely taken off for inspection. The points should have clean, flat surfaces at all times. Do not allow dirt or grease to accumulate on these points.

Connecting Spark Control.

In connecting spark control to circuit breaker control arm, be sure that both full advance and full retard positions are obtained and that movement is free and positive. The last link in the control mechanism should not cause any cramping or binding of circuit breaker at any position.

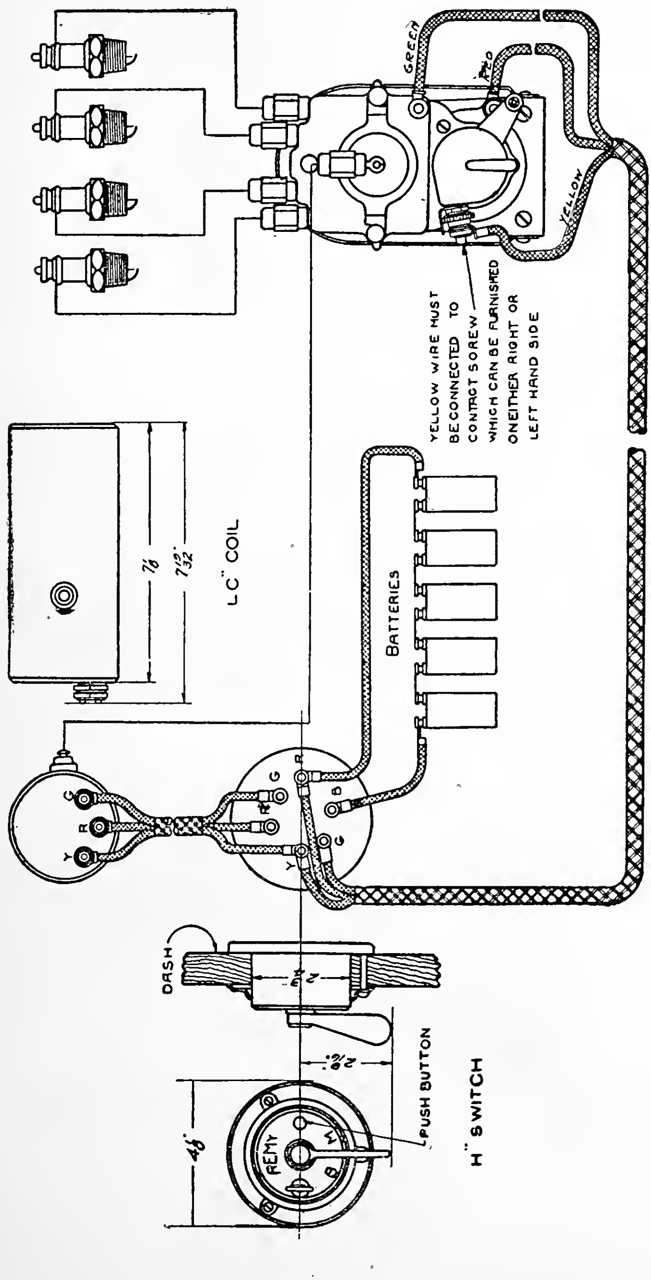


WIRING PLAN—R L MAGNETO WITH L E COIL
Fig. 20.



WIRING PLAN—R L MAGNETO WITH L C COIL AND D SWITCH

Fig. 21.



WIRING PLAN—R L MAGNETO WITH L C COIL AND H SWITCH

Fig. 22.

SIMMS HIGH TENSION MAGNETO SYSTEMS.

A gasoline engine requires regular sparks at certain predetermined positions of the crankshaft, and as the high tension magneto is capable of producing two sparks per revolution, 180 degrees apart, it is obvious that magneto must be driven at a fixed speed ratio to the crankshaft, this ratio depending upon the number of sparks required by the engine per revolution. So, for four-cylinder, four-cycle engines the magneto must be driven at crankshaft speed. For four-cylinder, two-cycle engines, the magneto must be driven at twice crankshaft speed. For six-cylinder, four-cycle engines, the magneto must be driven one and one-half times crankshaft speed, and for six-cylinder, two-cycle engines the magneto must be driven three times crankshaft speed. See Figs. 23, 24, 25, 26, 27, and 28.

The magneto must be driven by positive gearing, or in case silent chain is used for driving, care must be exercised to see that possible back-lash is prevented, and in no case should the attempt be made to drive the magneto by means of friction devices.

The cam which actuates the contact breaker is made of hardened steel, and accurately ground. This insures perfect timing and prevents uneven wear.

Three oilers are provided: one on the driving end plate, the other two at the top of the distributor end plate. These oilers lubricate all bearings in the magneto and should be given three or four drops of light machine oil every thousand miles. Care should be taken to not over-lubricate and the contact breaker should never be oiled. These magnetos are made to run only in the direction shown by engraved arrow on the driving end plate.

MAINTENANCE INSTRUCTIONS.

Timing of Ignition.

To time magneto to motor, turn engine over until No. 1 cylinder is on top dead center with valves closed (beginning of working stroke, with connecting rod swung over on downward stroke side); remove the contact breaker cover and distributor board; turn magneto armature in the direction it must run until the platinum contact screws are just opening with the timing lever in the full retard position (the retard position is obtained by pushing the timing lever down in the same direction the magneto armature rotates). The distributor carbon brush must at the same time be in position to touch the distributor segment serving cylinder No. 1. Driving gear or coupling should be securely tightened on magneto armature driving shaft, using key in keyway provided on shaft.

Magneto can now be coupled to the engine (care being taken not to change the foregoing adjustments) and wired according to the firing order of the engine. It must always be remembered that the distributor brush rotates in the opposite direction to the armature, and that No. 2 terminal on the distributor does not necessarily lead to No. 2 cylinder of the engine, but to the cylinder firing after that to which No. 1 leads. The same applies to the rest of the terminals.

Any advance or retard desired in addition to that to be obtained by the variation of the timing lever, must be secured on the engine alone, by advancing or retarding the engine timing gears, but in no case should the setting of the magneto distributor or internal armature gears be changed, as they have a certain fixed relation to each other.

Different settings of these two gears will seriously impair the efficiency of the magneto.

Oiling Magneto.

The magneto should be oiled every two weeks, or each 1,000-mile run, with 4 or 5 drops of light machine oil (not cylinder oil), in each of the oil holes, which are located over the armature driving shaft, and at the top of the distributor board at

the back. The contact breaker should never be oiled. It may cause serious difficulty if oil is allowed to remain on it.

Care of Contact Breaker.

The platinum points should be set so as to open on each cam about one-sixty-fourth of an inch, or the thickness of an average business card. The points should be kept clean and free from oil, and make flush contact with one another. The bell crank lever should pivot freely in the housing, which can be slightly reamed out if sticking. The contact breaker should be inspected occasionally, and freed of dirt and oil. Only, if it should become absolutely necessary, should the platinum points be trued with a very fine flat file.

Distributor Board.

Cable connections should be kept tight and occasionally the inside of the board wiped with a dry cloth to remove any oil or dirt. The distributor carbon brush should at all times press firmly against the board.

Safety Spark Gap.

The safety spark gap is to protect the insulation of the magneto armature from injury caused by excessive voltage, which would occur should a high tension connection come loose or be taken off, as the spark will then jump at the safety gap. If sparking should be detected in the safety gap, the high tension wiring should be gone over carefully at both the magneto and spark plug ends. The distributor carbon brush and the conductor bar should be examined to see if they are in place and making contact. Also see that the spark plug points are not more than one-fiftieth (.020) of an inch apart. If sparks can be obtained at the safety gap, it is an indication that the magneto is generating, and that the trouble is most likely in the wiring, as mentioned.

Attaching Couplings.

Care should be taken when driving couplings or gears are attached to or taken off the magneto armature shaft, that the slip ring on the armature is not cracked or broken by violence to the armature shaft or magneto end plate.

Spark Plugs.

The plug points should be set with a gap of about one-fiftieth of an inch. Greater distances than this will cause mis-firing at low speeds and sparks may also occur at the safety spark gap. Testing spark plugs out of the cylinders will not give accurate information, as the compression of the cylinder is absent. The plug may also be short-circuited by carbon. If the plug has a cracked insulator, the spark may short-circuit in the cylinder, but may spark properly when out.

Wiring.

Cables should be of good insulation and not allowed to become oil soaked. The cables should not be wrapped or grouped in a non-metallic tube. Separate them about one-half inch, or run them through a metal tube, care being taken to prevent cables from being chafed at points where they enter or leave the tube. Terminals should always be used on the cable, as otherwise loose strands of wire may cause short-circuiting.

Switch.

Should the ignition stop suddenly, the trouble is most likely in the switch. Remove the magneto cable leading to the switch and see if the magneto will then operate. Also remove the commutator cover on the magneto, in case the trouble should be there.

Dual System.

The care of the magneto is the same as the independent systems, but the magneto commutator must be wired strictly in accordance with diagrams, as it will not work if the cables are reversed. Where dry cells are used, the pasteboard covers may chafe through or become wet, grounding the ignition entirely, or cutting out two cylinders.

WIRING DIAGRAMS

TYPE SU4

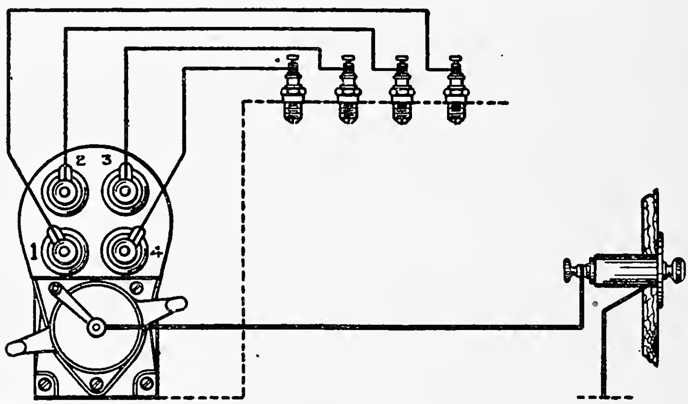


Fig. 23. SU4 Clockwise Magneto

WIRING DIAGRAMS

TYPE SU6

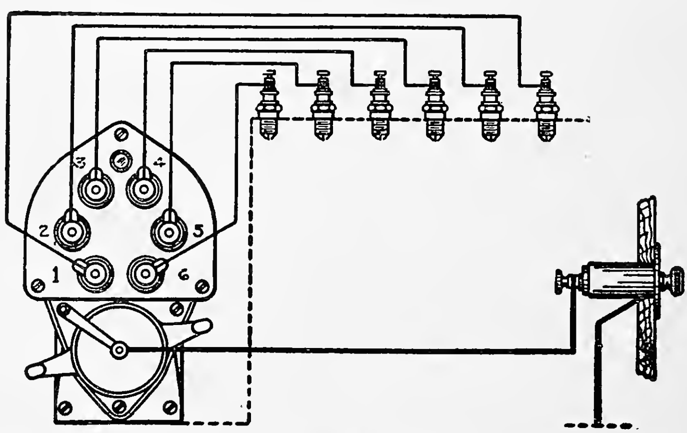


Fig. 24. SU6 Clockwise Magneto

WIRING DIAGRAMS

TYPE SU4-S

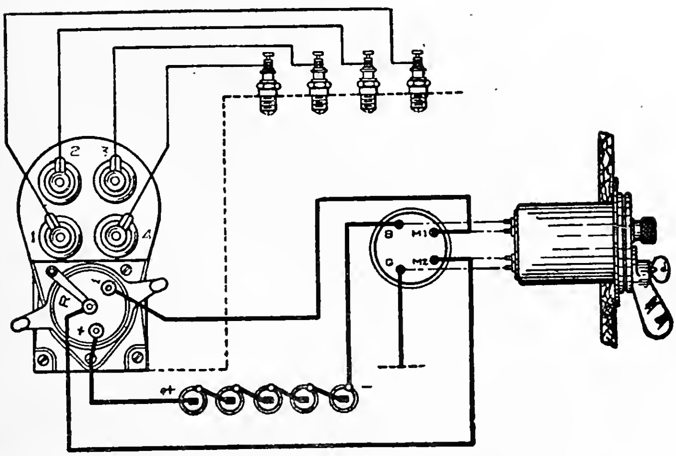


Fig. 25. SU4-S Clockwise System

WIRING DIAGRAMS

TYPE SU6-S

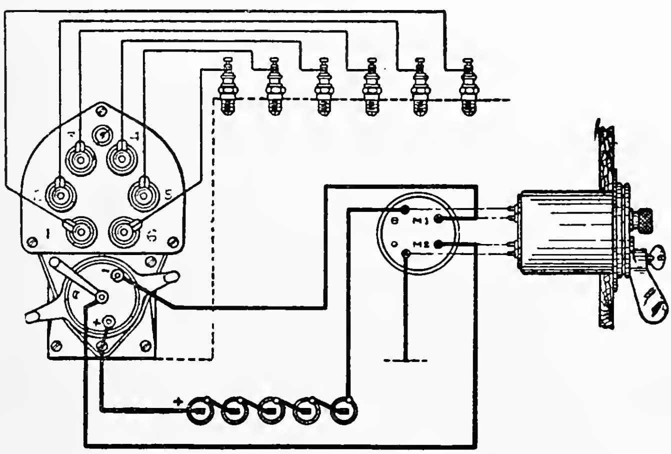


Fig. 26. SU6-S Clockwise System

WIRING DIAGRAMS
TYPE SU4-D

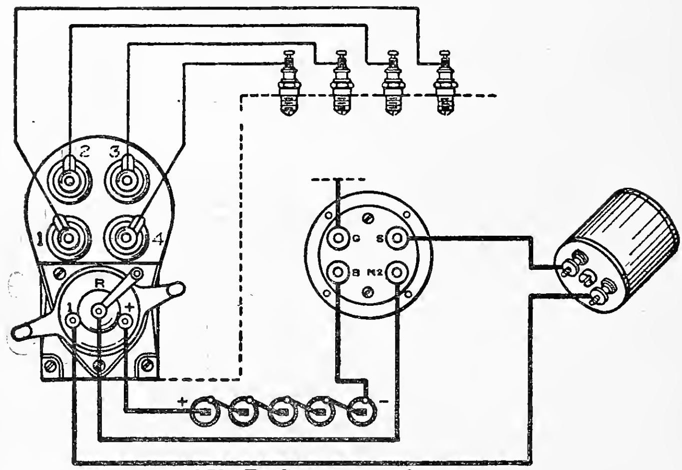


Fig. 27 SU4-D Clockwise System

WIRING DIAGRAMS
TYPE SU6-D

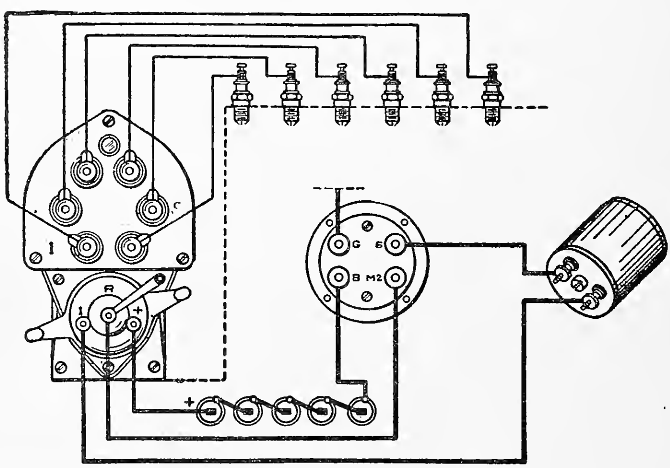


Fig. 28. SU6-D Clockwise System

SPLITDORF MAGNETO IGNITION, MODELS A, AW, AX and W, X, Y, AND Z.

The four-cylinder models, A, AW, AX, and X runs at crank shaft speed, and six-cylinder models, Y and Z, at one and one-half crank shaft speed. The drive should be either geared direct to the crank shaft, or by means of a universal coupling known as the Oldham Coupling. The latter method is very much to be preferred to the former, because the accurate setting and alignment absolutely necessary with the direct gear on the armature shaft is not essential with the latter method. See Figs. 29, 30, 31, 32, and 33.

There is another drive possible—the chain—but on account of the many wearing points, back slack, and other faults, this should only be used where gear drive is impossible on account of inaccessibility, or where a large number of gears are objectionable.

If the Oldham drive is employed, the driving flange is first slotted to fit the Woodruff key supplied with the magneto and then fitted. The other flange of the coupling is left loose on the end of the pump shaft or other shaft used to drive the magneto, and the cross block is slid into place.

Installing.

After securing the magneto to the prepared base on the motor, crank engine until cylinder No. 1 is exactly on firing center, that is, the point of greatest compression. The motor must remain in this position until the balance of the work is finished.

Retard the spark advance mechanism at the steering wheel to its limit and connect it to the spark advance lever on the breaker box of the magneto, so that if the magneto shaft revolves in a clockwise direction looking at the driving end, the breaker box lever will be at its topmost position. If the shaft revolves lefthanded the lever should be at the bottom limit, and advanced upward.

Now revolve the armature shaft in direction of its rotation until the oval breaker cam comes in contact with the roller in the breaker bar and just begins to separate the platinum points. The flange of the coupling can then be drilled and reamed for a taper pin, and the timing of the magneto is then effected. Then connect the terminals of the magneto to those of the transformer, as shown in the wiring diagram.

After ascertaining the position of the bronze sector of the distributor, connect the cup directly over it to the spark plug in cylinder No. 1. Since the direction of rotation of the distributor is always opposite to that of the armature shaft, the wire from the cup next in rotation goes to the next cylinder in sequence of firing, and so on until all wires are connected.

On six-cylinder types it is always best to find out from the manufacturer or agent how the motor fires, because there are a number of ways it can fire, and unless connected up in the right sequence of firing, the results will be very bad.

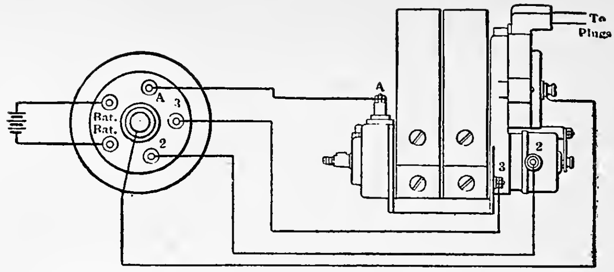
In starting the motor, always retard mechanism to its limit, throw the switch on the transformer to the side marked "Battery," and crank the motor.

If it is desired to start on the magneto side, ignoring the battery entirely, advance the spark mechanism about half way or two-thirds of the way and crank as before. No backfire should take place.

Do not drive the motor with the spark retarded, but as far advanced as the motor will permit. This is easily ascertained after driving the car a few times.

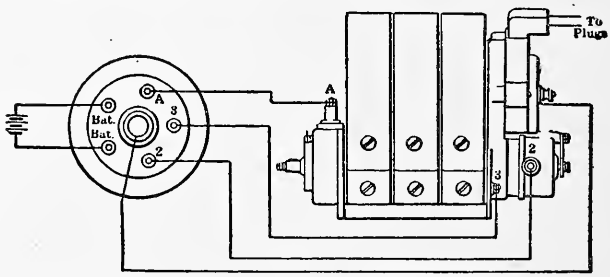
All of these magnetos can be changed to run in either direction. To change from one direction to the other, remove the breaker box, hold the driving end of the armature shaft firmly with a pair of gas pliers, and remove the little nut which holds the same in place. Pull off the cam which is keyed on with a Woodruff key, turn the cam over, replace the cam and nut and reset nut on the shaft with a

Fig. 29.



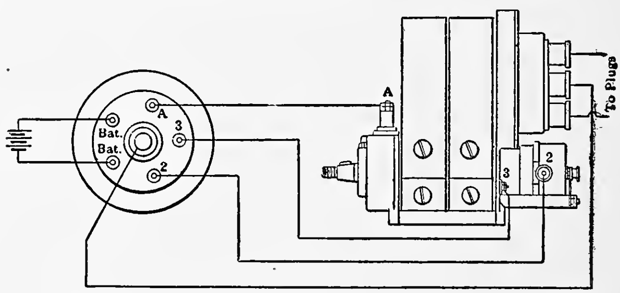
Wiring Diagram of Model X Magneto and "T S F" Transformer

Fig. 30.



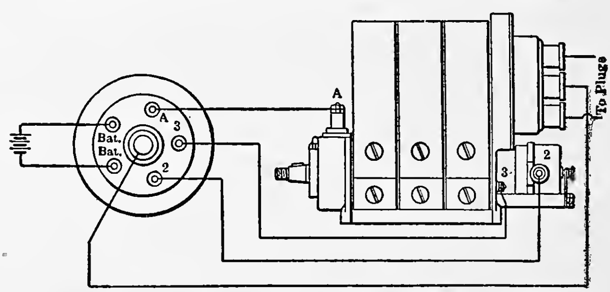
Wiring Diagram of Model W Magneto and "T S B" Transformer

Fig. 31.



Wiring Diagram of Model Y Magneto and "T S F" Transformer

Fig. 32.



Wiring Diagram of Model Z Magneto and "T S B" Transformer

prick punch so that it will not jar loose. Then remove the distributor block. Also remove the insulated brush that is located at the driving end of back plate of magneto, take out the four screws that hold same, then remove back plate and slide armature back. This will bring the two gears out of mesh. Then set the armature back in mesh so that the position of the segment will agree with either Fig. 34 or Fig. 35, according to the direction of rotation.

All of these systems absolutely require that both poles of the battery be brought to the transformer. The battery must not be grounded under any circumstances.

If the platinum points, after much usage, become pitted so that a bad contact results, they can be dressed flat with a fine file, being careful to not file off more than is absolutely necessary. When resetting these points be sure that the cam is in the proper position and that the points open not more than .025 of an inch.

The gap of all spark plugs used with these magnetos should be about 1-32 inch and no more. Be careful not to over-lubricate the magneto bearings, but be sure to oil them sufficiently once every two weeks with good oil.

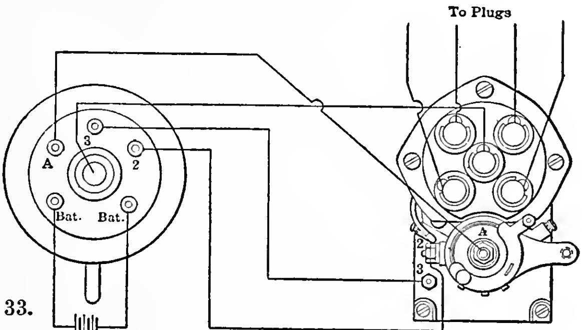
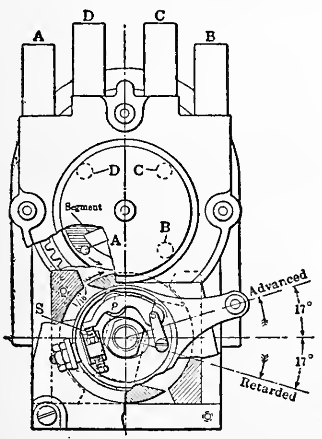


Fig. 33.

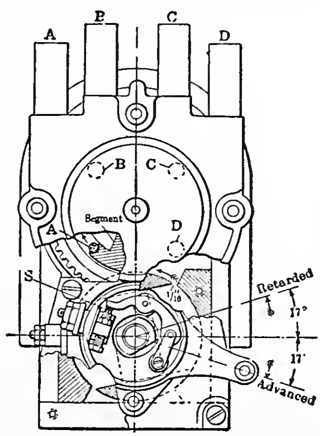
Wiring Diagram of Model A Magneto and "T S A" Transformer

NOTE.—On Models AX and AW Magnetos the wire leading to "Post A" on the Transformer is connected to the Brush Holder at the driving end of the Magneto.



Left Hand Magneto.
Looking at Machine from Driving End Points (S) about to Open as Armature Core leaves Pole Piece about 1/16" Segment just under Brush.

Fig. 34.



Right Hand Magneto.
Looking at Machine from Driving End Points (S) about to Open as Armature Core leaves Pole Piece about 1/16". Segment just under Brush.

Fig. 35.

SECTION 8

ELECTRIC TESTING

Starting, Lighting and Ignition Systems

ELECTRIC TESTING

Starting, Lighting and Ignition Systems.

Realizing that nearly every motor car mechanic is called upon daily to repair or adjust something about the electric system on motor cars, we have gathered the data contained in this book and have pictured the tests in a way that they should be easily understood.

Electric troubles are easily located and remedied if the mechanic understands the simple principles of electricity and electric terms.

To all who are new at this line of work we especially recommend our No. 1 book entitled Elementary Electricity, Motor Car Electric Systems and Delco Light. This book explains the meaning of electric terms in a way that they are easily understood. The instruction on elementary electricity is such that many of the best schools in the world have adopted this book for their elementary text.

The operation of an electric system is often compared to that of a water system as their operations are similar in nearly every way. Figures 1, 2, 3 and 4 are used to explain the first principles of the operation of a water system which may be compared to that of an electric system.

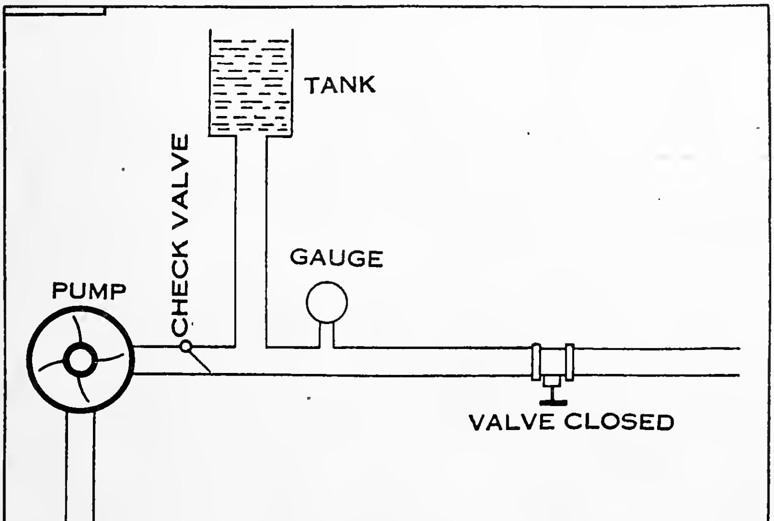


FIG. 1

In **Figure 1**, the pump compares with the electric generator, the check valve with the cut-out relay, the valve with a switch, the pressure gauge with a voltmeter, and the tank with a storage battery. When the pump is operated and the pressure of the pump becomes greater than that of the tank, the check valve opens and water flows to the tank.

As soon as the pressure of the pump falls below that of the tank, the check valve

closes and prevents the water in the tank from flowing back to the pump and being wasted. The pressure gauge shows the pressure in pounds.

When an electric generator is operated and the pressure of the generator becomes greater than that of the battery, the cut-out relay closes and permits current to flow to the battery. As soon as the pressure of the generator falls below that of the battery the cut-out relay opens and prevents the current from the battery flowing back upon the generator and being wasted.

A voltmeter shows the electric pressure in volts. When the valve in the water line is opened, water will flow. When a switch used in an electric system is closed current will flow.

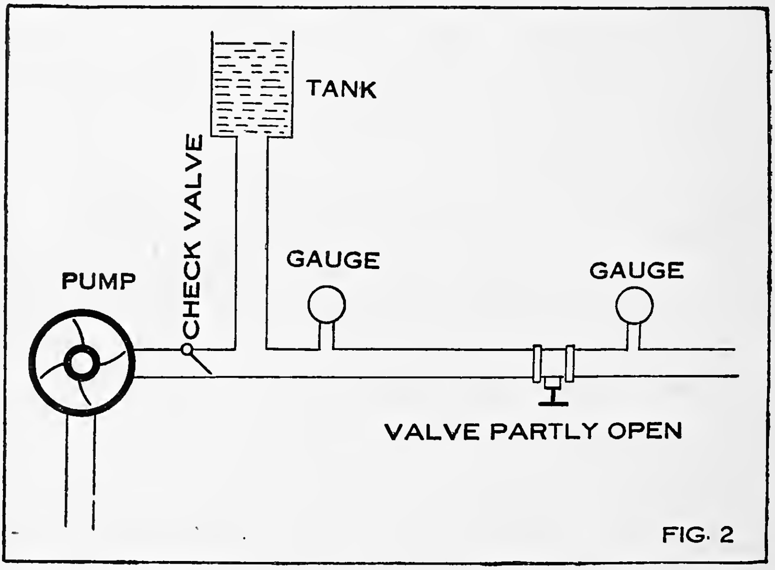


FIG. 2

Figure 2 is the same as Figure 1, excepting that two pressure gauges are used instead of one and the valve is partly open. If the pressure gauge nearest to the tank shows 50 pounds pressure, the pressure shown by the other gauge will be less, due to the resistance offered to the flow of water by the valve, which is only partly open.

The resistance offered to the flow of water by the valve in this system compares with poor switch contacts or a high resistance joint or connection in an electric system.

Figure 3 shows a clog in the pipe. If the valve is all the way open the pressure shown by the gauge nearest the tank will be much greater than that shown at the other gauge, due to the resistance offered to the flow of water by the clog in the pipe. The clog in the pipe of this system compares with poor joints or connections in an electric system.

Figure 4 shows a clog in the pipe from the main line to the tank. If the pump is operating, the pressure shown by the pressure gauge will be extremely high, due to the resistance offered to the flow of water to the tank, by the clog in the line. If the pump is not being operated and water is taken from the tank, the pressure shown by the pressure gauge will be extremely low as the clog in the pipe will prevent a full flow of water.

It often happens with an electric system that when the generator is supplying current for lights or other demands that the voltage rises extremely high, and

when the generator is not running, the current then being supplied by the battery, the voltage will be extremely low.

When the generator is supplying the current the lights are exceptionally bright,

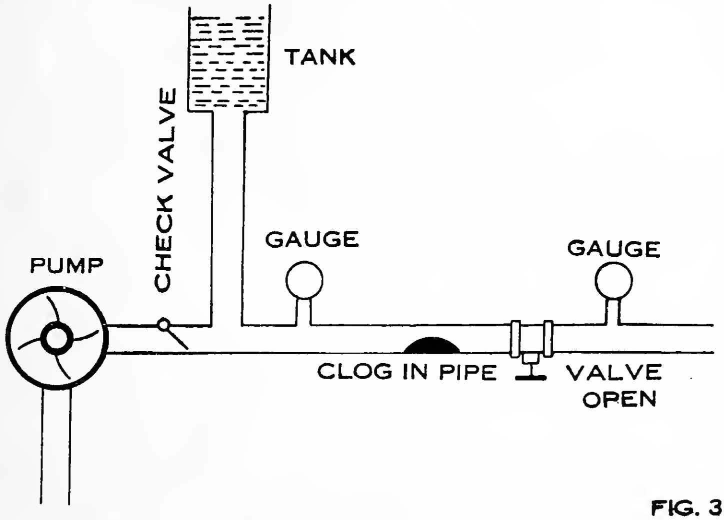


FIG. 3

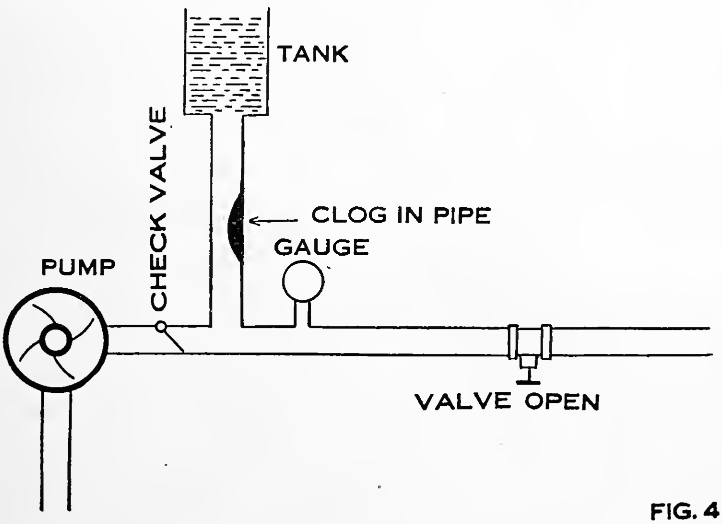


FIG. 4

and when the battery is supplying the current the lights are exceptionally dim. In this case we always find a poor connection in one of the battery lines between the switch and storage battery. In the water system the clog in the pipe compares with the poor or loose connection in the electric system.

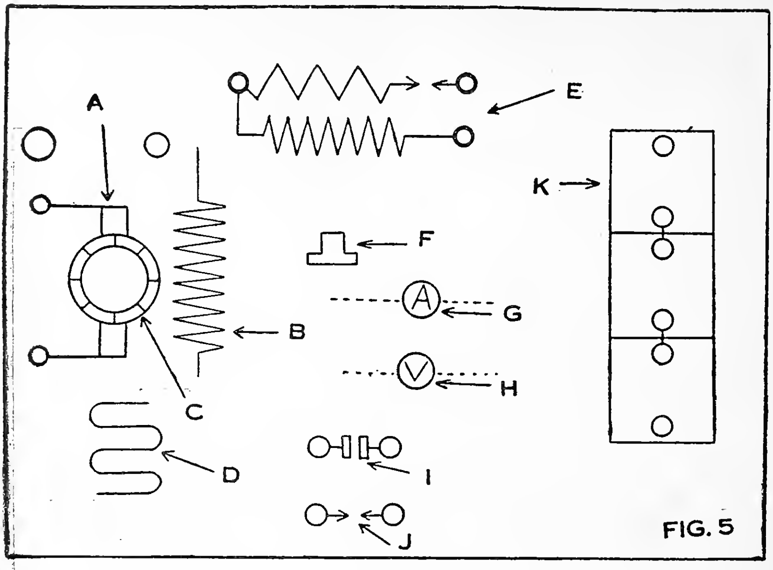


FIG. 5

Figure 5 shows a number of symbols which are used in the various illustrations. A shows a motor or generator brush. B a field coil. C a motor or generator commutator. D shows resistance wire. E shows a cut-out relay. F is a push button. G is an ammeter. H is a voltmeter. I and J are contacts. K is a storage battery. Study these symbols carefully and compare them with those used in the illustrations. In doing so the illustrations and parts will be more easily understood.

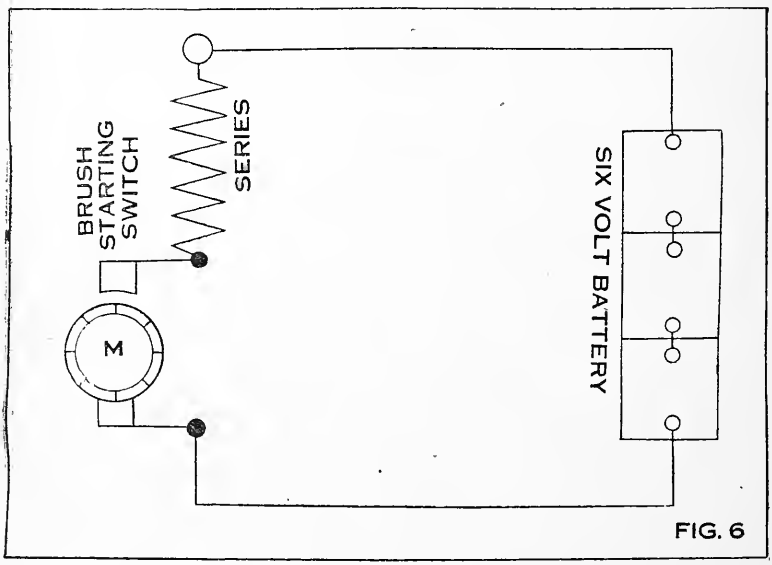


FIG. 6

Figure 6 shows a cranking circuit with the brush lifted. When the brush is lowered and comes in contact with the commutator, the motor will operate. The upper brush acts as a starting switch. When the systems being tested are of the

single wire type, the lower line from the battery to the generator or the motor should be considered the same as "Ground" or "Frame of Car." This applies to all illustrations of this nature.

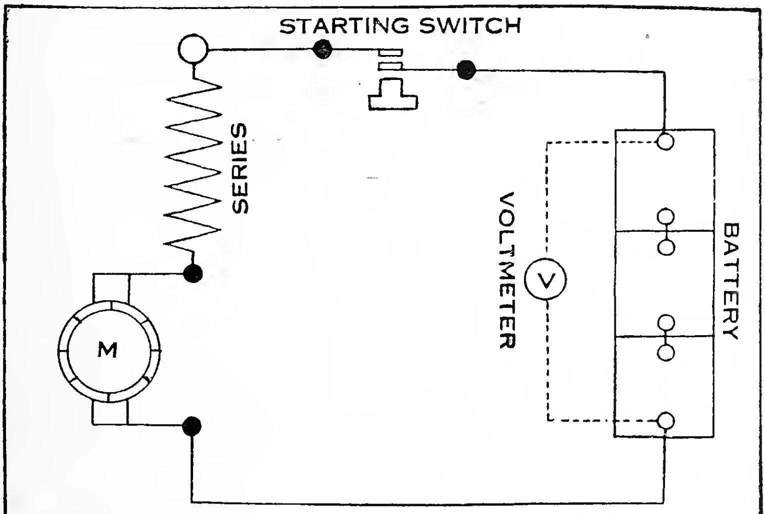


FIG. 7

Figure 7. A switch is used in the cranking circuit showing the contacts open. When a voltmeter is connected at the terminals of the battery as shown, it should always show six volts or a little over. In this case the battery is idle. This test is of little value, as it is not an assurance that the battery is charged or is good.

A battery while idle may show a pressure of six volts, and when put under a load the voltage will drop excessively. Should the voltage drop excessively, the battery is weak, due to discharge, or may be defective.

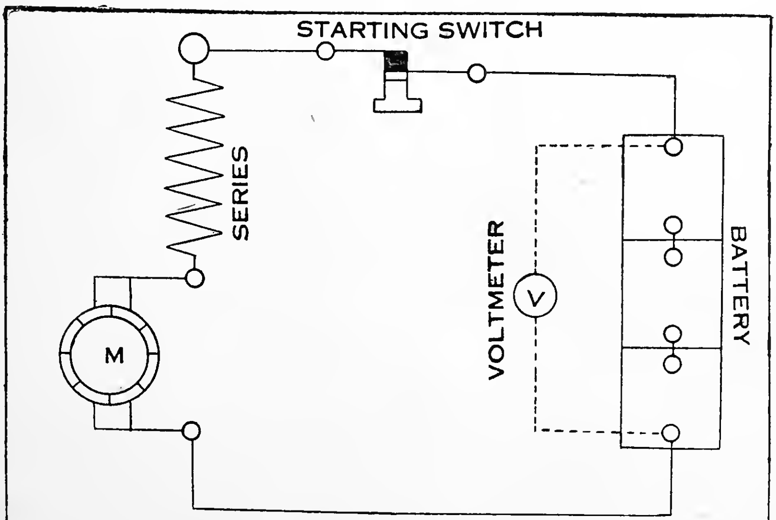


FIG. 8

Figure 8. This shows the starting switch closed and the voltmeter connected across the terminals of the battery. If, when the starting switch is closed, the voltage drops excessively, the battery is at fault and the trouble is likely to be a discharged or defective battery. If the voltage drop is not over 1½ volts, the battery is all right.

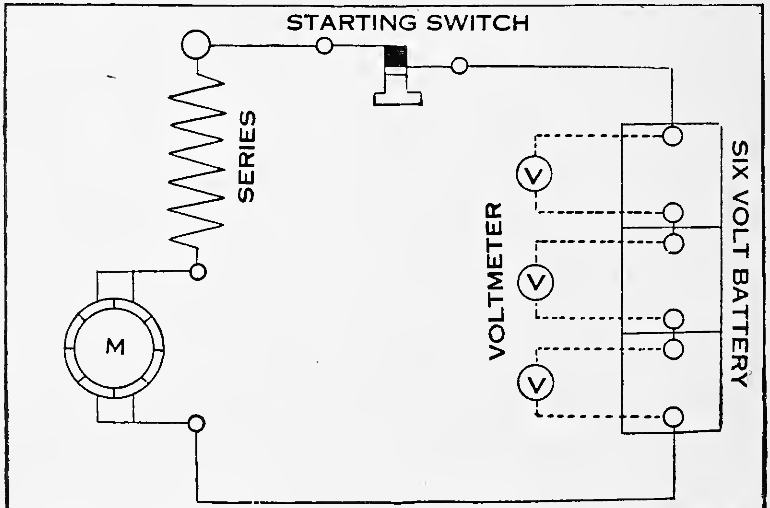


FIG. 9

Figure 9. This shows the starting switch closed and three positions of the voltmeter connected across the terminals of single cells. If the voltage dropped extremely low when making test as shown in Figure 8, then tests as shown in Figure 9 should be made, taking voltage of each cell separately.

If the voltage of all cells is low, then it is likely that the battery is weak, due to discharge. If part of the cells show the voltage to be all right and others show low voltage, it is likely that the ones showing low voltage are defective. To be sure of this, first try charging the low cells individually and see if they can be brought up to a charged condition. Then make test again as shown in Figure 9.

Figure 10. This shows the starting switch closed and the voltmeter connected to the terminals of the wires at the battery. If voltage was all right when test was made at the terminals of the battery, as shown in Figure 8, and there is a decided drop in voltage when test is made as shown in Figure 10, the terminal connections at the battery are loose or corroded.

If a corroded condition is found they should be cleaned at once. To remove corrosion, first take all of the battery bolts, nuts, and washers off of the battery and put them in a strong solution of cooking soda and water. Let them remain in this solution for 10 or 15 minutes. Then use a stiff brush on them and be sure they are clean.

It may be necessary to scrape them entirely to remove the corrosion. After they are cleaned they should be given a good coat of vaseline. Clean the terminal posts of the battery with the same solution, being careful not to allow the solution to get into the battery. Be sure to give all terminal parts a good coat of vaseline before and after they are assembled. Then make test as shown in Figure 10. The voltage drop should not be excessive.

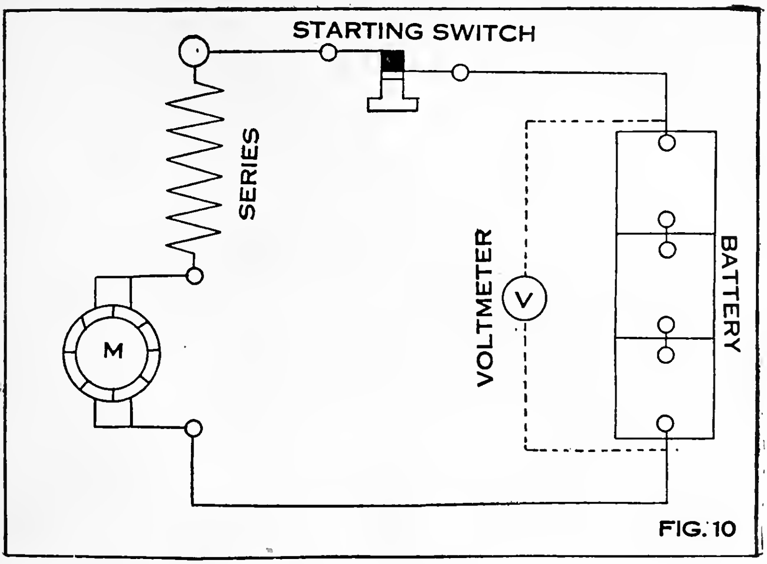


FIG. 10

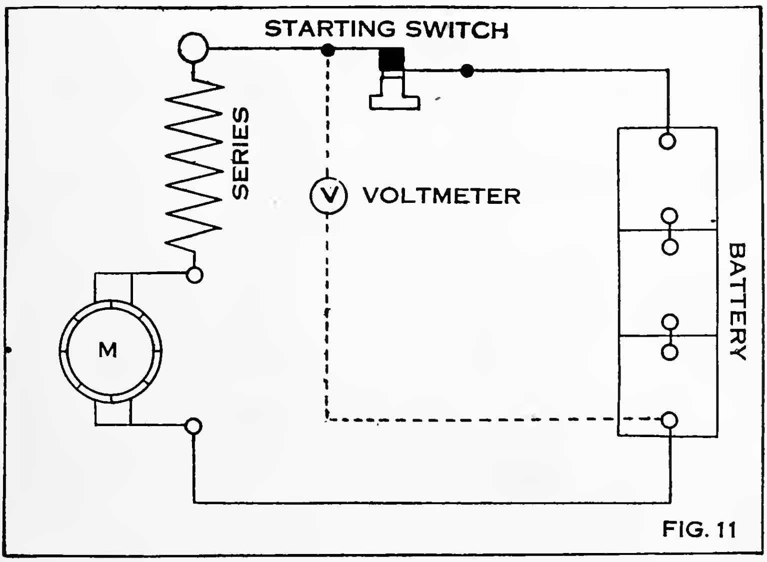


FIG. 11

Figure 11. This shows the starting switch closed and the voltmeter connected to one side of the battery and to one side of the switch. If the drop in voltage is great at this point, it is likely that the switch contacts are bad. To determine this, make test as shown in Figure 12.

Figure 12. This shows the starting switch open and the voltmeter connected across the terminals of the starting switch. The voltmeter should show the full voltage of the battery. Then make test as shown in Figure 13.

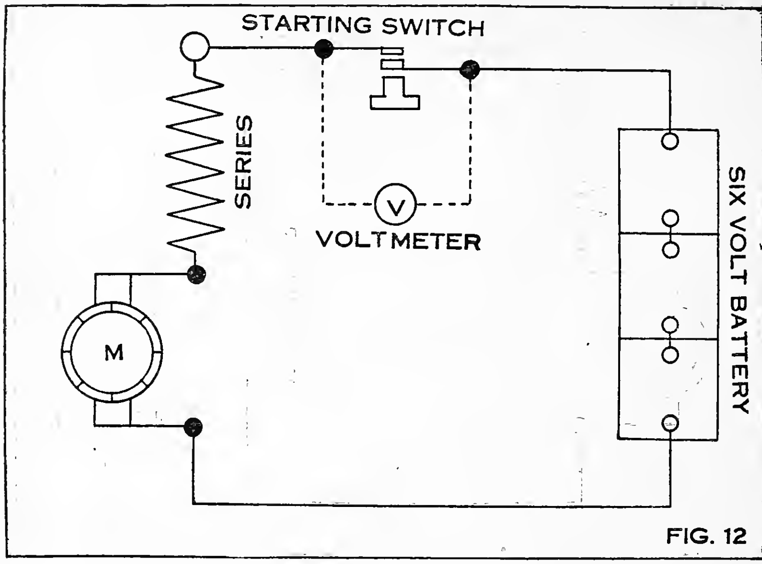


FIG. 12

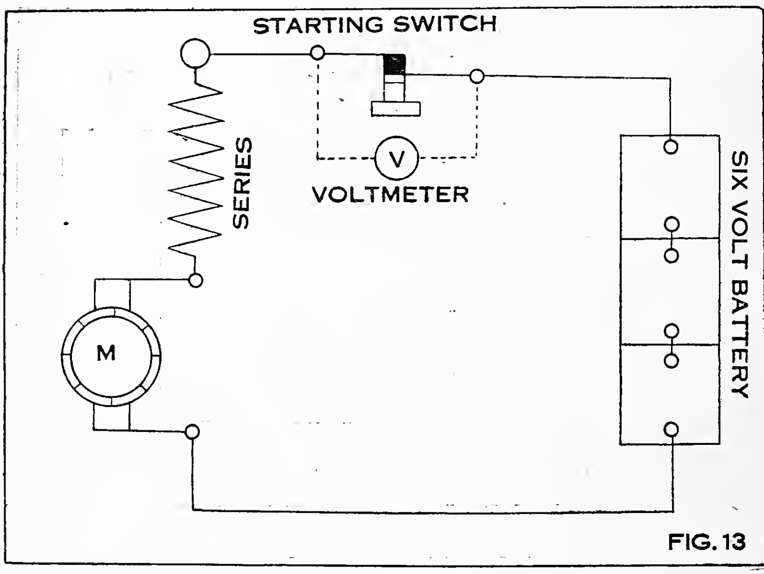


FIG. 13

Figure 13. This shows the voltmeter connected across the terminals of the starting switch and the starting switch closed. When the starting switch is closed, the voltmeter should not show a reading. If it does show a reading, the starting switch contacts are either dirty or defective.

Figure 14. This shows starting switch closed and voltmeter connected to the terminal of the motor and one side of the battery. If voltage is all right at this point and the starter fails to operate properly, it is an indication that the motor is defective.

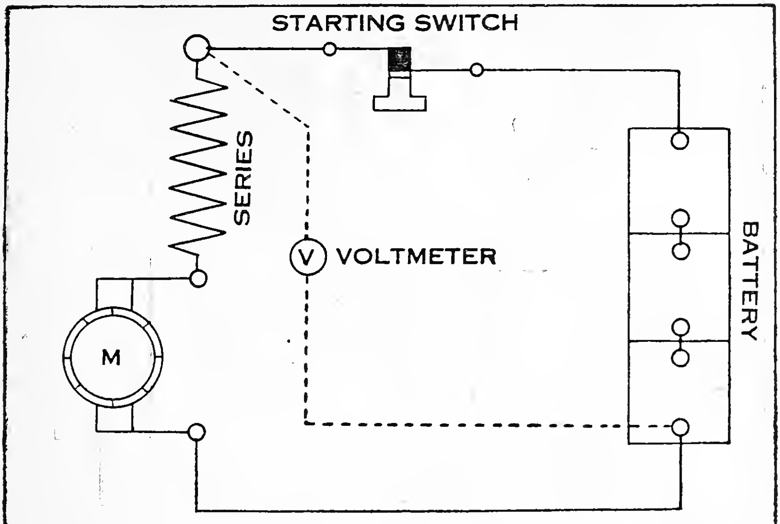


FIG. 14

The troubles may be due to worn-out motor brushes, brushes stuck up in holders, brushes not properly fitted to the commutator, weak brush-spring tension, dirty commutator, high micas, low segments, loose or poorly soldered connections, or open field windings. To test for open field windings, first make test as shown in Figure 14, and then make test as shown in Figure 15.

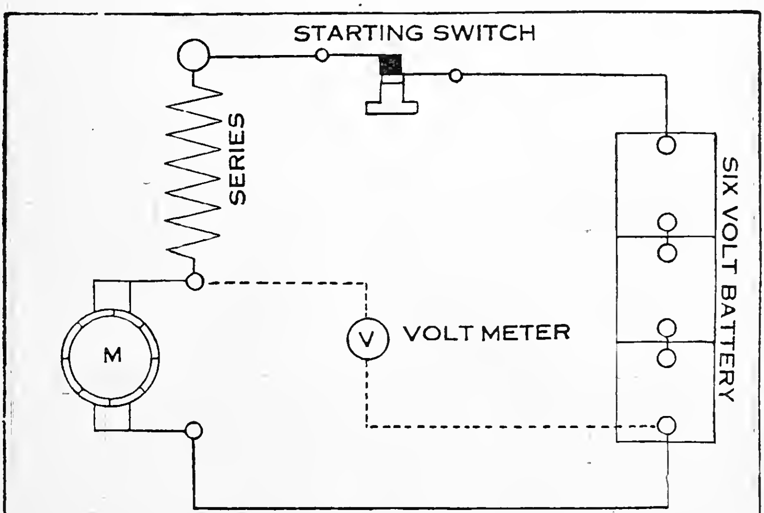


FIG. 15

Figure 15. This shows the voltmeter connected to the brush end of the field coil and to the battery. If voltage was all right when test was made as shown in Figure 14, and voltage is low or no voltage at all is shown in test Figure 15, the field coil is open or there are loose or poorly soldered connections to the field coil.

Be careful to note the position of the starting switch at all times. **WHEN VOLTAGE TESTS are made the starting switch should be closed.**

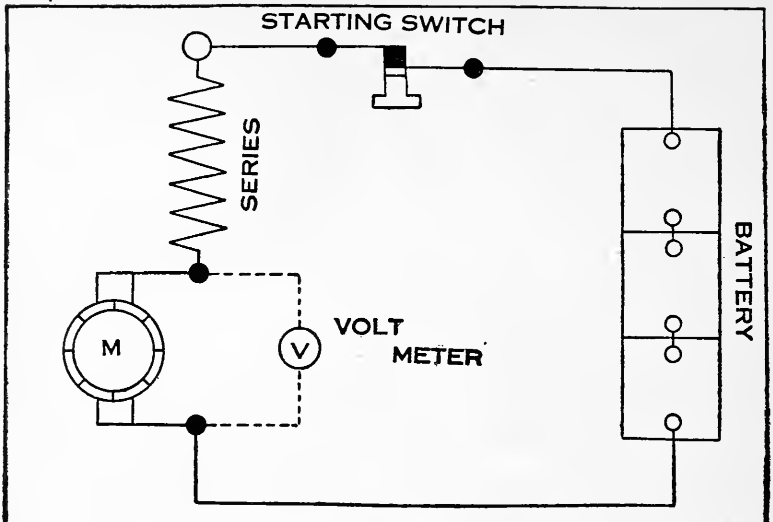


FIG. 16

Figure 16. This shows the starting switch closed and the voltmeter connected at the brushes of the starting motor. If voltage is all right at this point, then inspect the conditions of the commutator and brushes as described under Figure 14.

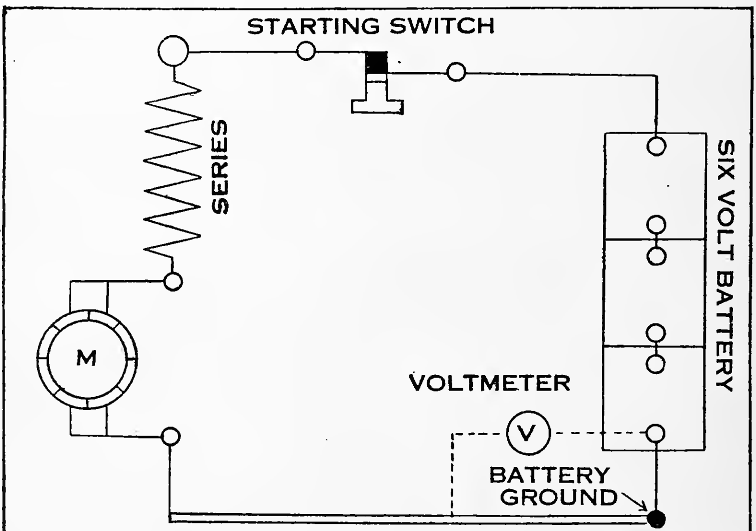


FIG. 17

Figure 17. This shows starting switch closed and the voltmeter connected to the ground terminal of the battery, and the other side of the voltmeter connected to the frame of the car. If the voltmeter shows a reading, the ground connection at the frame of the car is poor.

Remove the battery ground connection to the frame of the car and clean the connection as well as the frame of the car at the point where the connection is to be made. Then give the cleaned surfaces a good coat of white lead. Attach the

terminal to frame of car and be sure that a good, tight connection is made. Make test over again. Voltmeter will not show a reading then.

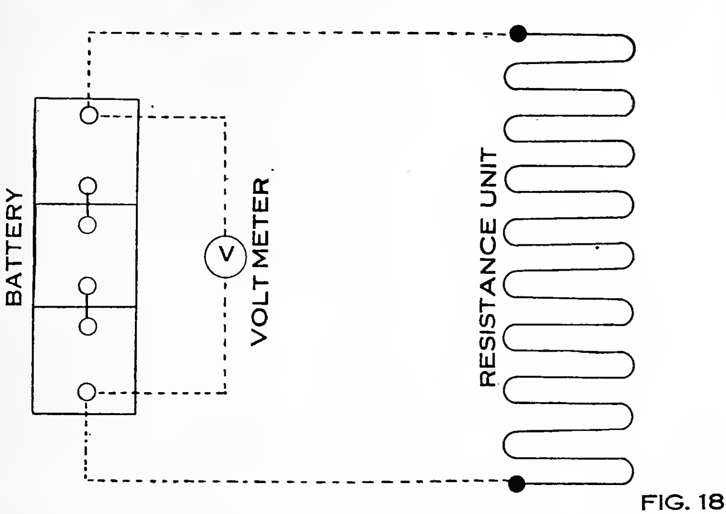


FIG. 18

Figure 18. This shows a method of testing a storage battery. To make this test, first secure 9 feet of No. 16 soft iron wire and wind it in the form of a spiral spring. Then stretch the spring so that when the ends are released that no two coils of the spring touch each other and short out a part of the wire. This may be used as a resistance unit. Then connect voltmeter as shown.

The voltmeter should indicate six volts or a little over. Leaving the voltmeter connected to the terminals of the battery, connect resistance unit as shown. If a decided drop in voltage is noted, the battery is either weak, due to discharge, or bad cells exist.

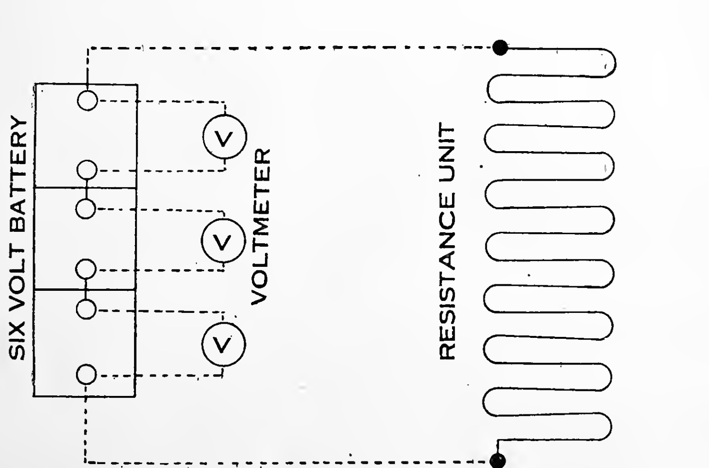


FIG. 19

Figure 19. This shows three positions of the voltmeter connected to a single cell. Leaving the resistance unit connected to the battery as shown in Figure 18, test each cell for voltage separately. If voltage of all cells is alike, the trouble is likely due to discharge. If the voltage of one or two cells is extremely low, it indicates bad cells.

Unless you are experienced in battery repairing, it is best to take the battery to a battery service station. When the resistance unit is connected at the terminals of the battery, as shown in Figure 18 and Figure 19, the battery is being discharged at about a 30-ampere rate.

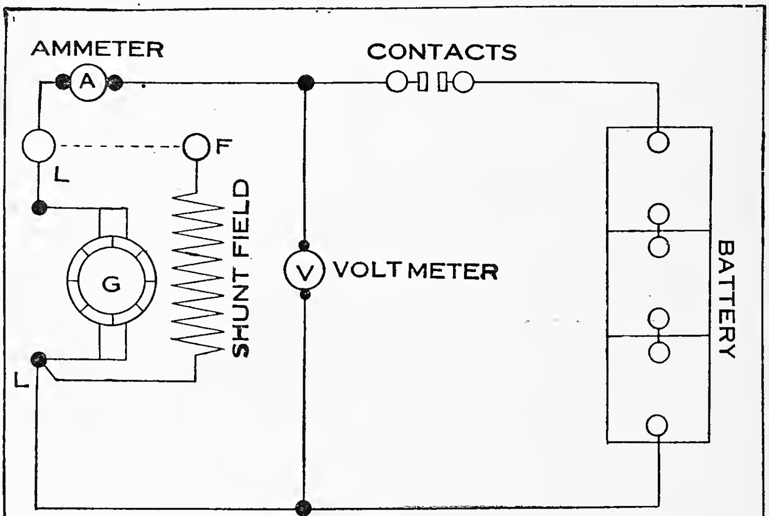


FIG. 20

Figure 20. This shows a generator wired to a battery with an ammeter connected in series with them and a voltmeter connected across the lines between the

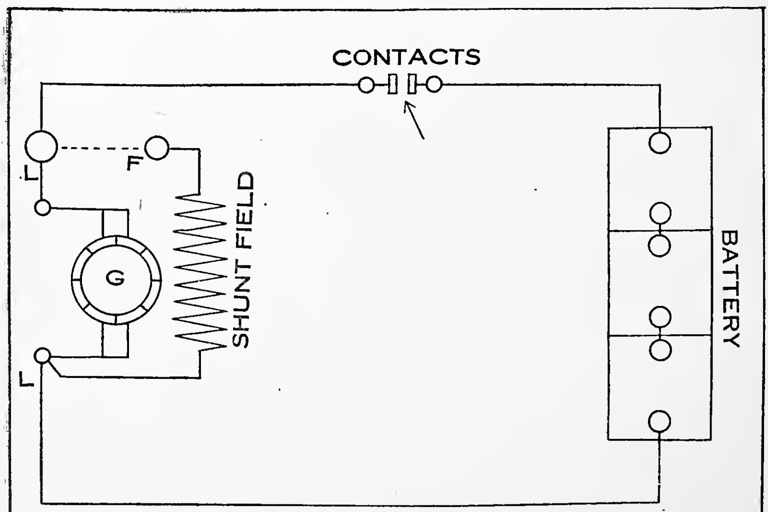


FIG. 21

generator and the battery. The circuit is completed by hand in this case. In many systems when the ignition switch is turned to the "ON" position it also causes these contacts to close.

The voltmeter shows the pressure of the generator and the ammeter indicates the output of the generator. Connected as shown, it will indicate discharge of the battery for lights or horn.

Figure 21. This shows a generator wired to a battery. Contacts are closed by hand. Note the dotted line between generator terminals. Field regulators should be connected to these two terminals in all generators where this dotted line appears between these terminals.

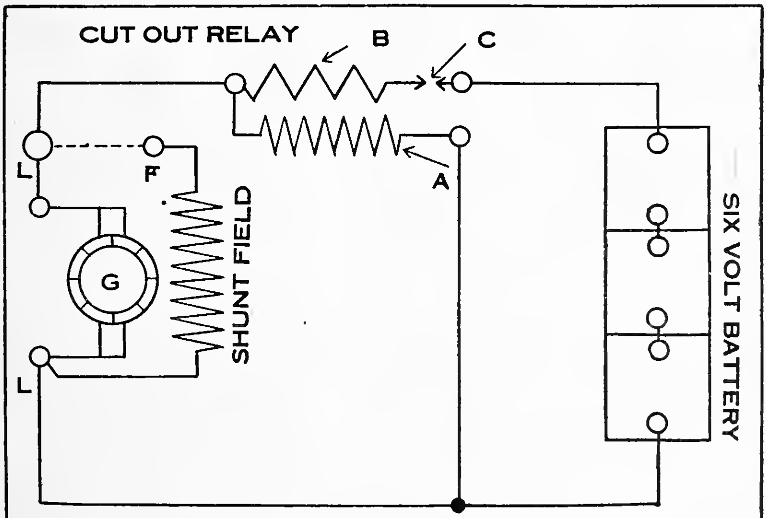


FIG. 22

Figure 22. This shows a generator wired to a battery with a cut-out relay connected in one side of the line. The cut-out relay takes the place of the contacts in the two preceding figures and is automatic. In this sketch "A" is the voltage winding, "B" is the primary winding, and "C" is the contacts.

Figure 23. This diagram is the same as Figure 22, excepting that the cut-out relay contacts are closed. The cut-out relay closes the circuit between the generator and the storage battery when the generator voltage is high enough to charge the battery.

It also opens the circuit as the generator slows down and its voltage becomes less than that of the battery, thus preventing the battery discharging back through the generator. The cut-out relay is an electro magnet with a compound winding. The fine voltage winding is connected directly across the terminals of the generator as shown.

The primary or coarse winding is in series with the circuit between the generator and the storage battery. The contacts are closed and opened at contacts "C" (see Figure 22). When the engine is started the generator voltage builds up, and when it reaches about 7 volts a current passing through the voltage winding produces enough magnetism to overcome the tension spring (see Figure 50), attracting the armature to the core which caused the contacts to close.

The contacts close the circuit between the generator and the storage battery.

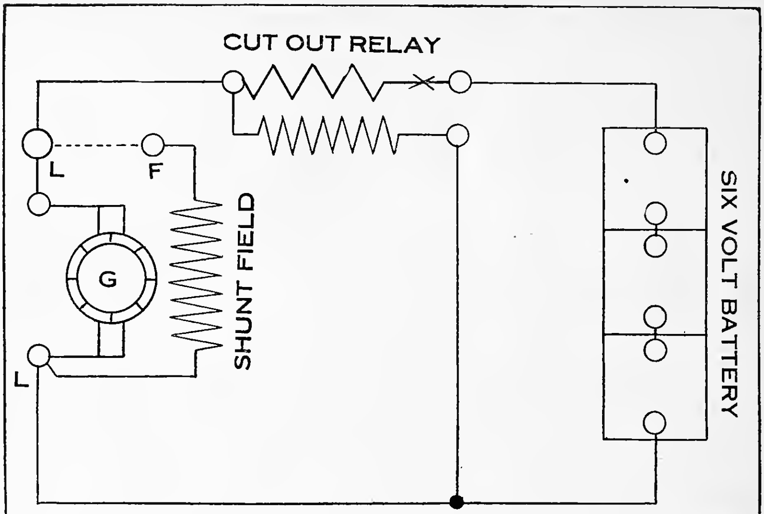


FIG. 23

The current then flowing through the coarse winding increased the pull on the armature and gives a good contact of low resistance at the contact points. When the generator slows down and its voltage drops below that of the storage battery, the battery sends a reverse current through the coarse wire windings which kills the pull on the armature.

The tenson spring then pulls the armature away from the core and the contacts are opened and will remain so until the generator is operated again.

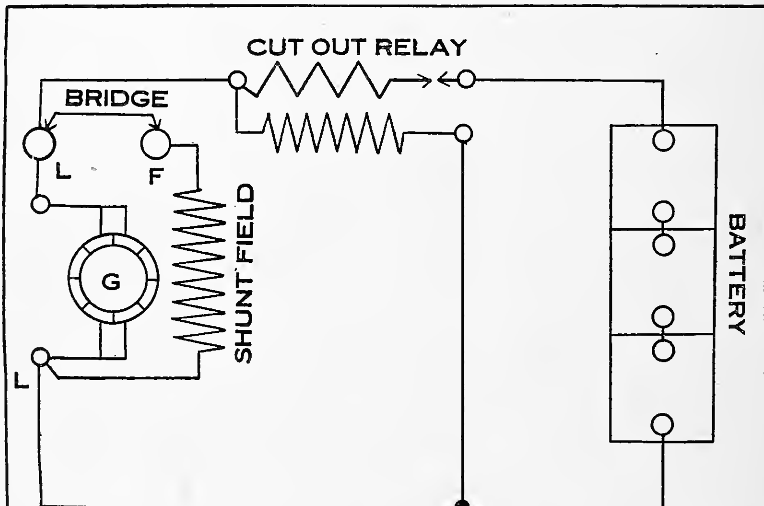


FIG. 24

Figure 24. This shows a bridge between terminals "L" and "F" of the generator. When an external regulator is used and generator does not generate, make test as shown by bringing these terminals together with a piece of wire. If generator now generates, the difficulty lies in the regulator or circuit to it. It may be said that the regulator circuit is open.

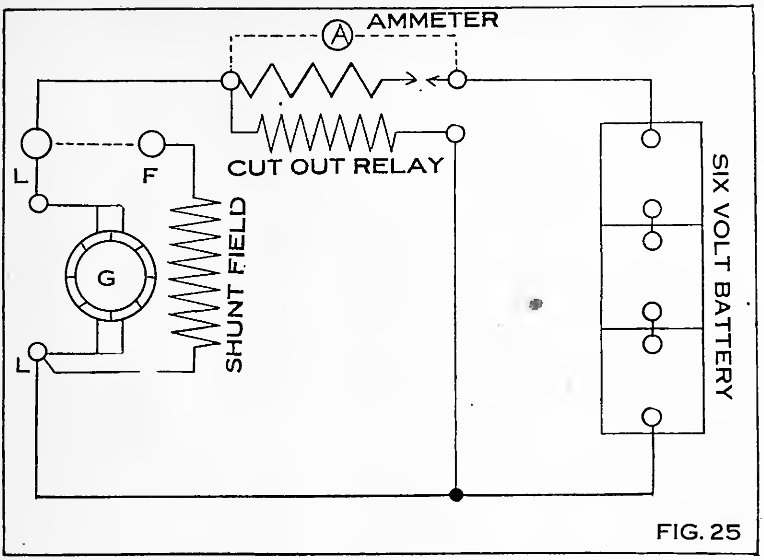


Figure 25. This shows an ammeter connected across the primary terminals of the cut-out relay. If, when the generator is running and it does not close at the proper time, test as shown. If generator is generating, the ammeter will show a reading. This indicates an open circuit in the primary or coarse wire circuit.

If, when armature is pressed and contacts are closed, the generator charges battery, look for open voltage winding.

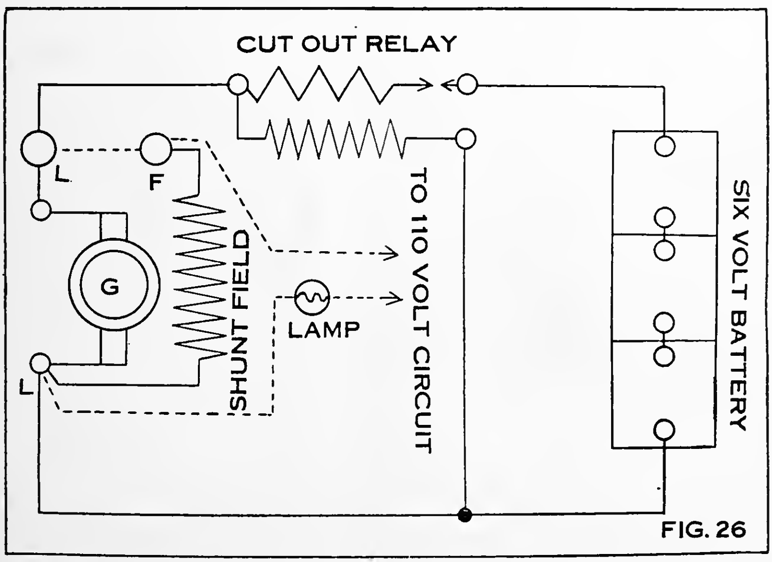


Figure 26. This shows test for open shunt field. Be sure to disconnect all wires from the generator. Then use test cord from 110-volt circuit, with lamp cut in on one side of the line as shown. If the lamp burns at all or there is a spark when the two points are touched as shown, the shunt field is not open.

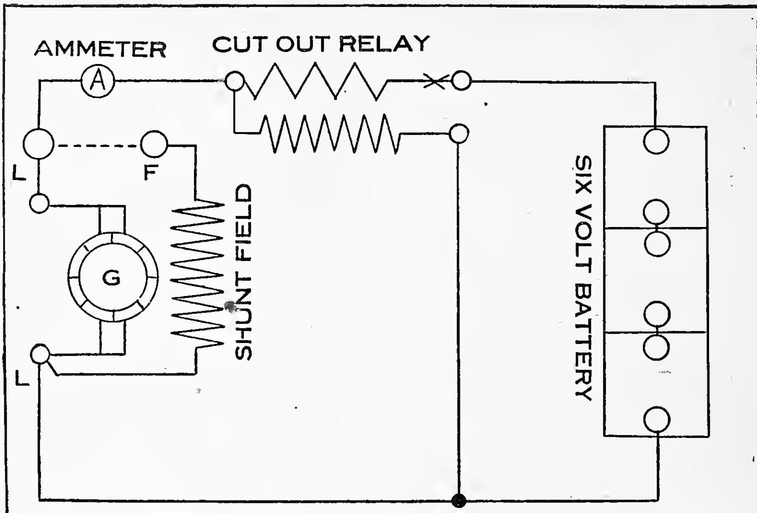


FIG. 27

Figure 27. This shows the ammeter connected near the generator terminal, which will show the output of the generator. In many cases short circuits occur in the lines between the generator and the storage battery. First make the test as shown, which gives the output of the generator. Then make test as shown in Figure 28.

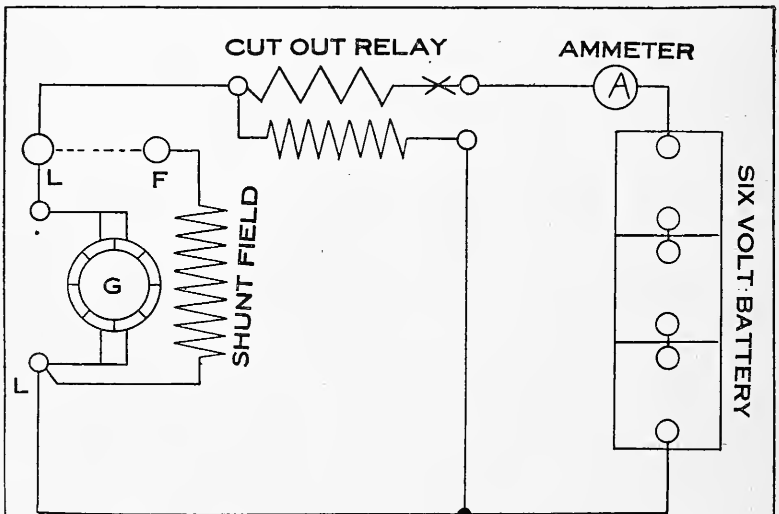


FIG. 28

Figure 28. This shows the ammeter connected in the circuit between the generator and the storage battery, near the battery. This will show the rate the battery is being charged. If the generator is generating current at a 15 ampere rate and the battery is being charged at a much lower rate, there is a loss in the line due to short circuits or grounds.

To make these tests be sure that your lights are not burning, and if ignition is taken from the generator system an allowance must be made for that.

Figure 29. To be sure that a cut-out relay is regulated right, connect the voltmeter across the generator terminals. Then have engine running. Watch the voltmeter and cut-out relay closely. When the voltage of the generator reaches seven volts, the cut-out relay should close.

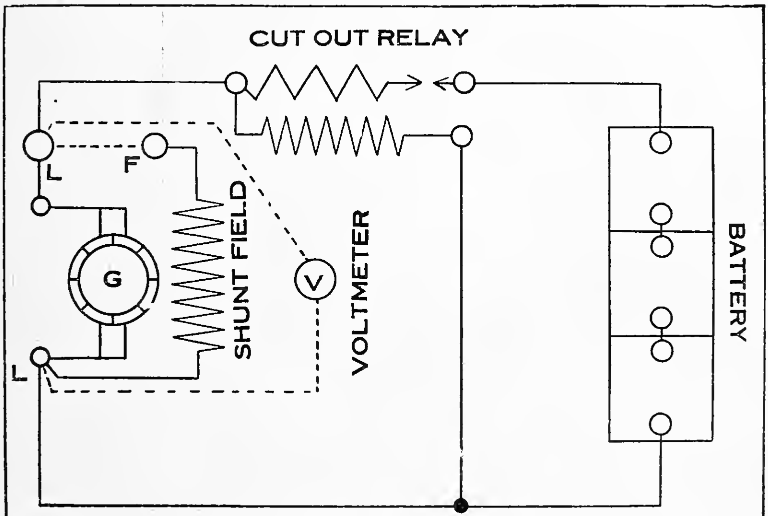


FIG. 29

If the two circuits are all right through the relay, then note the tension of the tension spring. If the relay closes too soon, stiffen the tension spring; if it does not close soon enough, weaken the tension spring. Do not change the tension of the spring very much at a time.

While doing this testing it is well to slow the engine down and then increase the speed slowly, watching the voltmeter and cut-out relay closely.

Figure 30. This shows the reverse series type of regulation. Note that the shunt winding is connected across the brushes and that the series is connected in series with the line and generator. When generator is generating the current from the generator must pass through the reverse series. This produces a bucking effect against the shunt winding.

As the speed of the engine increases, the bucking effect increases up to an average speed of 30 miles per hour. At that time the bucking effect will not let the shunt field build up any higher. It may be said that the generator will act as a constant current machine at all speeds above 30 miles per hour.

If it is necessary at any time to increase the output of the generator, short circuit the reverse series. If the generator is of the motor generator type, then be sure to remove this short circuit before attempting to crank the engine with the starter.

Figure 31. This shows the mercury-operated voltage regulator. The most important parts of the voltage regulator are as follows: Regulator or magnet coil, mercury tube, plunger, resistance wire, and mercury. The regulator or magnet coil surrounds the upper half of the mercury tube. Within the mercury tube is the mercury and plunger.

The plunger is an iron tube with a coil of resistance wire wrapped around the

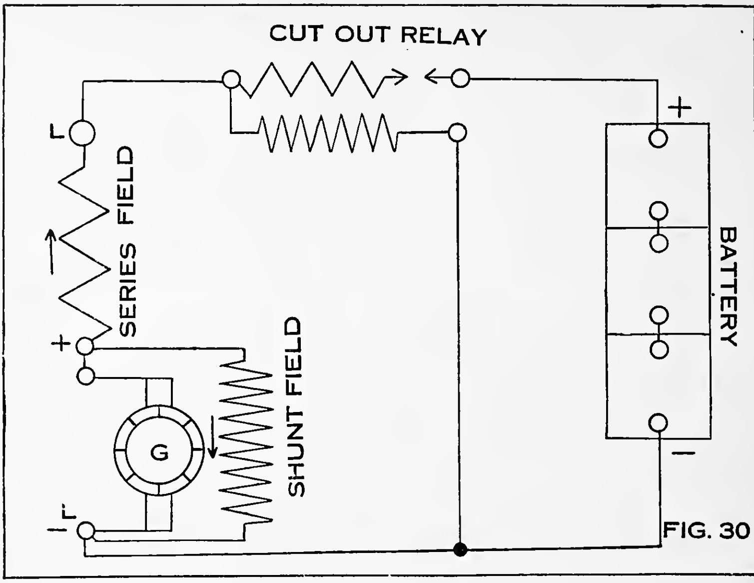


FIG. 30

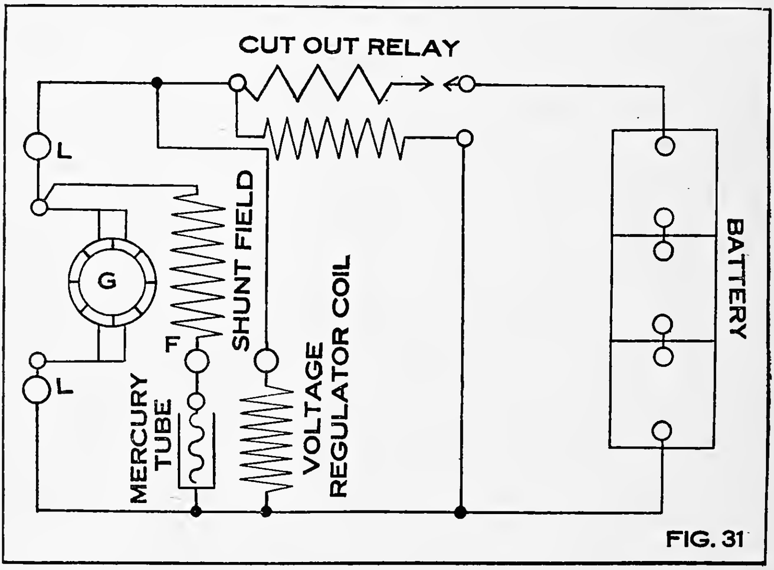


FIG. 31

lower portion on top of a special insulation. One end of the resistance wire is connected to the lower end of the tube and the other end is connected to a needle carried in the center of the plunger. The lower portion of the mercury tube is divided by an insulating tube into two concentric wells, the plunger tube being partly immersed in the outer well and the needle in the inner well.

The space in the mercury tube above the body of the mercury is filled with an especially treated oil which serves to protect the mercury from oxidization, to lubricate, and to form a dash pot for the plunger.

The operation is as follows: Inasmuch as the voltage of the storage battery

varies with its condition of charge, the intensity of the magnetic pull exerted by the regulator or magnet coil upon the plunger varies, and causes the plunger to move in and out of the mercury. When the battery is in a discharged condition the plunger assumes a low position in the mercury tube, and vice versa.

When the plunger is at a low position, the coil of resistance wire carried upon its lower portion is immersed in the mercury, and as the plunger rises the coil is withdrawn. Now the current to the shunt field of the generator must follow a path leading into the outer well of the mercury, through the resistance coil wound on the tube to the needle carried at the center of the plunger, into the center well of the mercury, and out of the regulator.

It will be seen that, as the plunger is withdrawn from the mercury, more resistance is thrown into this circuit, due to the fact that the current must pass through a greater length of resistance wire. This greater resistance into the field of the generator causes the amount of current flowing to the battery to be gradually reduced as the battery nears a state of complete charge until finally the plunger is almost completely withdrawn from the mercury, throwing the entire length of the resistance coil into the shunt field circuit, thus causing a condition of practical electric balance between the battery and the generator, and eliminating any possibility of overcharging the battery.

Figure 31 shows the mercury tube and resistance wire that is wound on the plunger. Also shows the regulator or magnet coil.

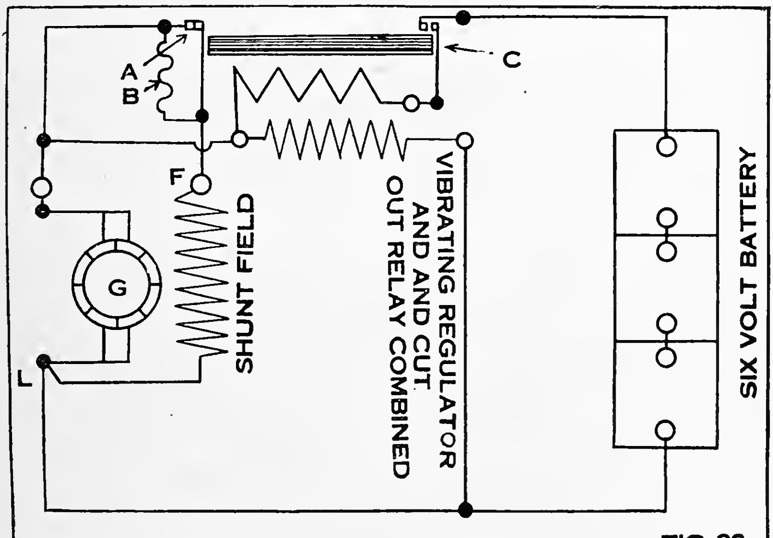


FIG. 32

Figure 32 shows the vibrating regulator type of regulation. In this figure is shown a combination cut-out relay and vibrating regulator combined in a simplified form, so they may be easily understood.

The relay core is shown above the coarse winding. "A" is the regulator contacts, "B" is regulator resistance, and "C" is the armature of the cut-out relay. The operation of the cut-out relay is practically the same as described under Figure 23. The regulator is set so as to start to vibrate when the output of the generator reaches a certain amount.

Each time the armature of the regulator is pulled toward the core of the regulator, contacts "A" are opened, inserting resistance "B" into the circuit. This reduces the current that passes through the shunt fields. At higher speeds the regu-

lator vibrates faster and keeps the resistance in the circuit a greater portion of the time, thus making the generator act as a constant current machine at higher speeds.

Ninety-five per cent of all troubles of a vibrating regulator occur at the regulator contacts "A." They become dirty or burned. If burned, smooth them up with a fine jeweler's file and then finish with real fine sandpaper. If they are only dirty, use only real fine sandpaper. When doing this work be careful not to change the tension on the springs containing the contacts.

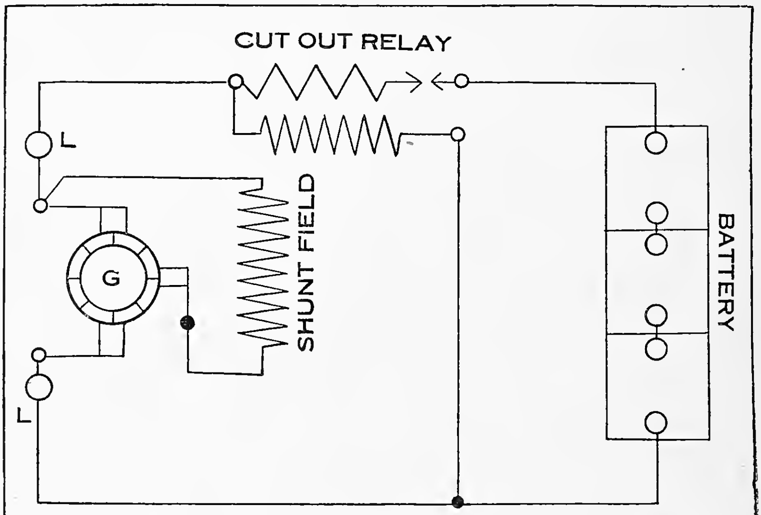


FIG. 33

Figure 33. This shows the circuits of a generator employing third brush regulation.

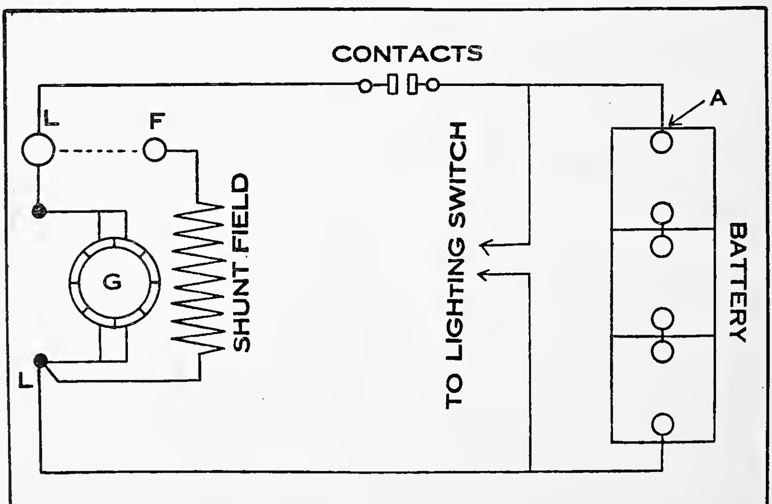


FIG. 34

Figure 34. This shows the lighting wires tapped off the two lines from the generator to the storage battery. There is a corroded joint, or connection, at "A." When the generator is running and supplying current to the system, the lights would be exceptionally bright; and when the current for the lights is taken from the battery, the lights are dim. This is due to the corroded or high resistance connection, as shown.

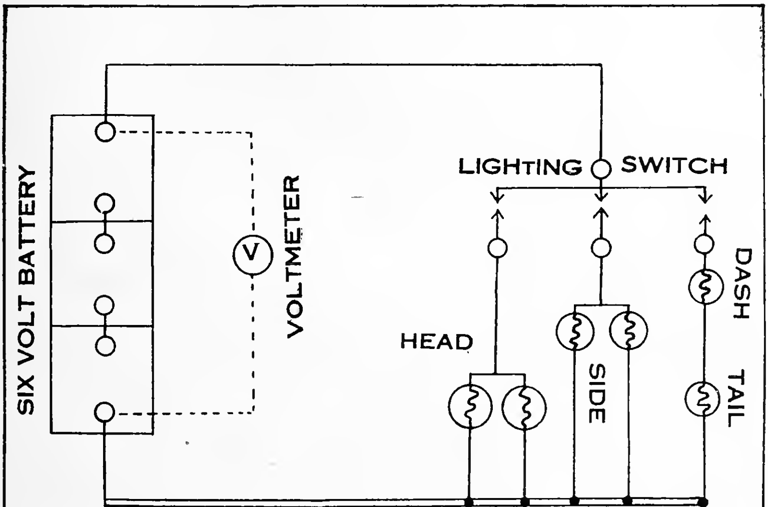


FIG. 35

Figure 35. This shows a standard lighting circuit with the voltmeter connected across the terminals of the battery and switch contacts open. The voltmeter indicates the battery voltage, battery idle.

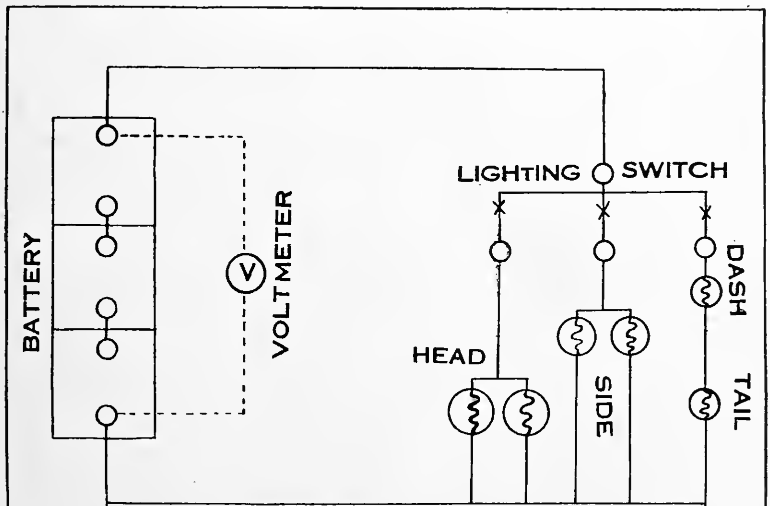


FIG. 36

Figure 36. This shows same circuit as in Figure 35, excepting that the lighting switch contacts are closed. If the battery is good and is charged, the voltage

should not drop so as to be noticeable. If it drops when lights are turned on, make test as shown in Figure 37.

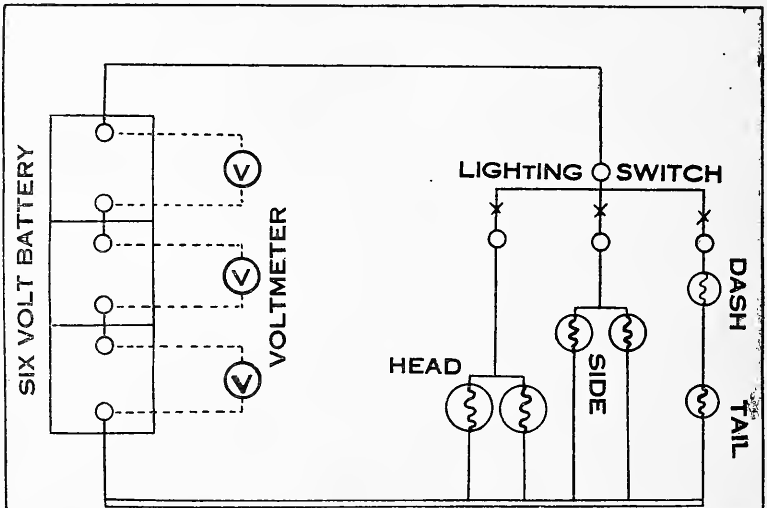


FIG. 37

Figure 37. This shows same circuit as in Figure 36, excepting that three positions of the voltmeter are shown. If voltage dropped when making test as shown in Figure 36, test each cell separately for voltage, being sure to have all lights on. If one cell is lower than the rest it may be bad. If all cells show a voltage alike, it indicates discharge.

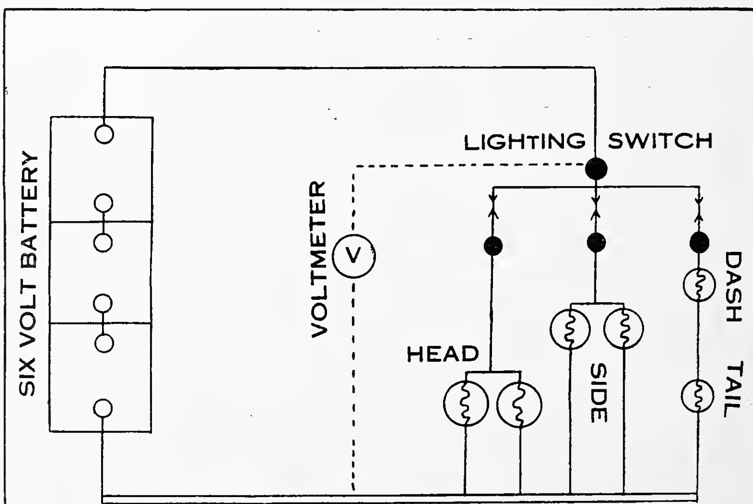


FIG. 38

Figure 38. This shows same circuit as in Figure 37, excepting that the voltmeter is bridged across the lights and lighting switch. This gives the voltage up to the lighting switch. Full battery voltage should be maintained up to this point.

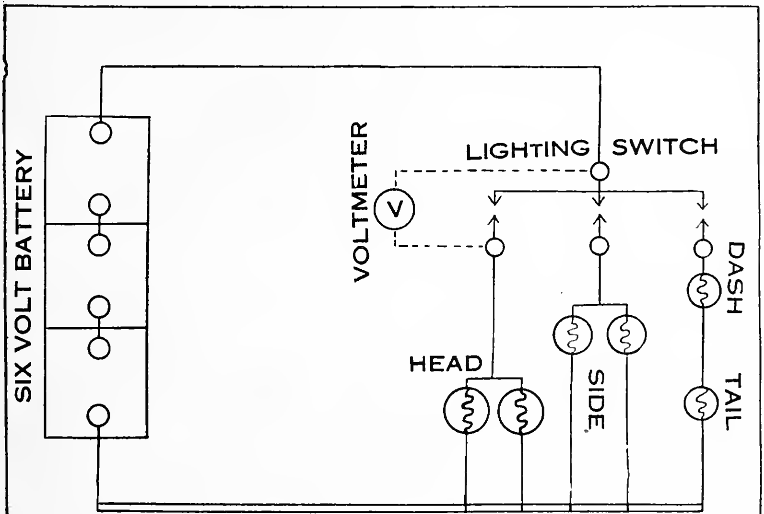


FIG. 39

Figure 39. This shows same lighting circuits as in Figure 38, excepting that the lighting switch is in the off position and the voltmeter is connected across the contacts of the headlight circuit. The voltmeter should show the full voltage of the battery.

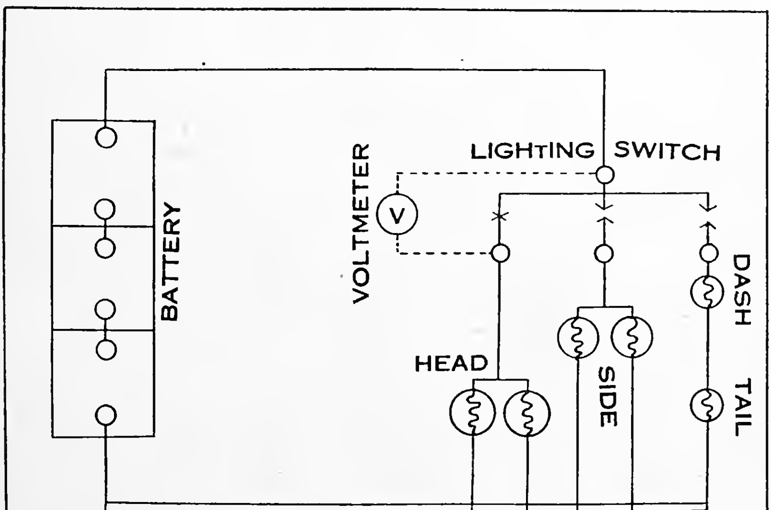


FIG. 40

Figure 40. This shows same lighting circuit as in Figure 39, excepting that headlight switch contacts are closed. When headlights are turned on, the voltmeter should not give an indication. If it does, the switch contacts are bad or there is a bad connection in the switch in this circuit.

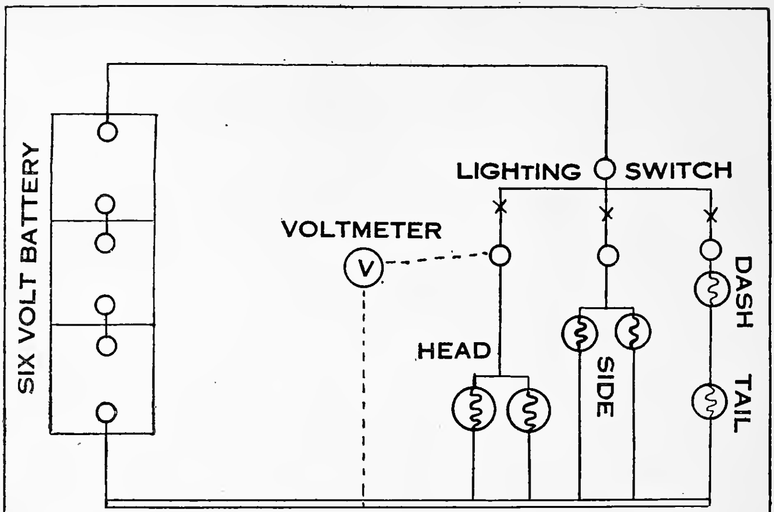


FIG. 41

Figure 41. This shows same circuit as in Figure 40, excepting that all switch contacts are closed and the voltmeter is bridged across the headlights from the switch to the opposite side of the line. The voltmeter should show full voltage up to this point.

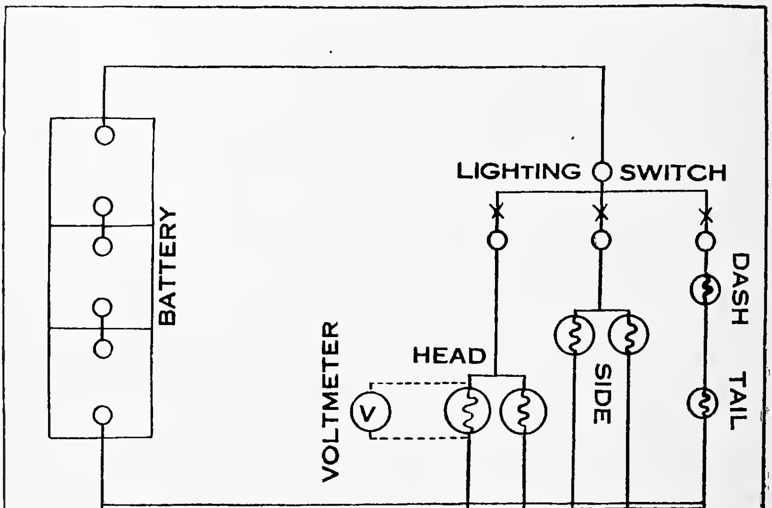


FIG. 42

Figure 42. This shows same circuit as in Figure 41, excepting that the voltmeter is connected directly across the headlights. There should not be a drop of over one-half volt over that of a reading taken at the terminals of the battery. If voltage is all right up to this point, and the light burns exceptionally bright, the voltage of the lamp used is too low for the system.

If the voltage is all right and the lamp burns exceptionally dim, the lamp is of too high voltage for the system or is old and nearly burned out.

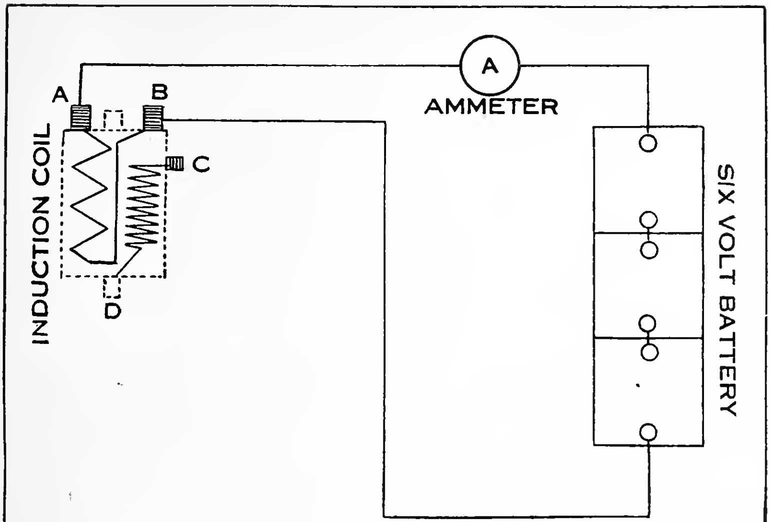


FIG. 43

Figure 43. This shows the primary winding of an induction coil as used for ignition purposes connected in series with an ammeter and a six-volt storage battery. This is a practical test for open or partially short-circuited primary winding.

If ammeter does not show a reading, the primary winding is open. With the primary winding of an induction coil connected in the circuit as shown, about ten amperes will flow. This will vary with the different makes of coils. If an excessive amount of current flows, it indicates a partial short circuit of the primary.

To be sure of this, first take a coil that is good and note the amount of current that will flow through the primary. Then try the same test with the coil that is to be tested. Be sure that the coils used in these tests are of the same make and construction. If in doubt at any time as to the construction of a coil, write its manufacturers for this information.

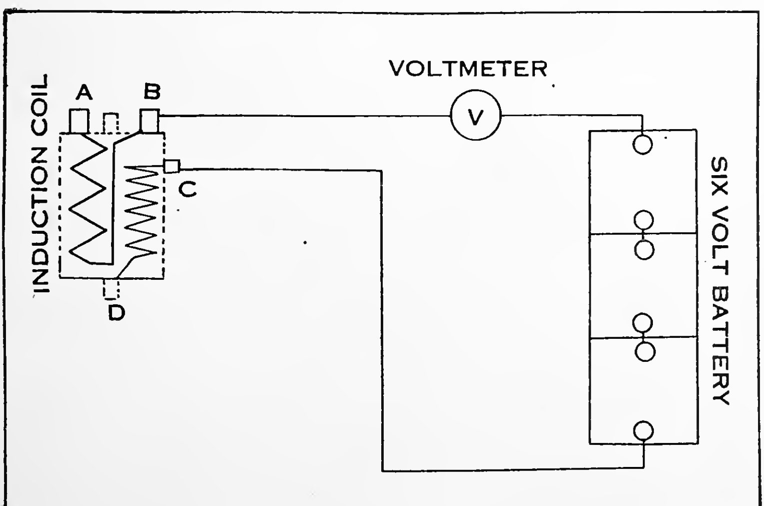


FIG. 44

Figure 44. In this diagram one side of the circuit is connected to one end of the primary of the induction coil, and the other side of the circuit is connected to the secondary winding of the coil. If the voltmeter shows a reading, these two windings are either connected together in the construction of the coil or they are shorted together. In the construction of some coils the primary and secondary are connected together, while in others they are not connected. Be sure of this when making tests. Note in Figures 43 and 44 that the secondary is not connected to the primary.

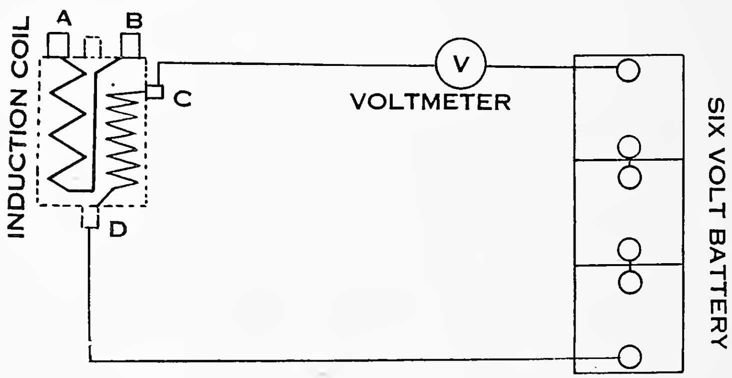


FIG. 45

Figure 45. This shows same coil as shown in Figure 44. The voltmeter is connected in series with the secondary winding and a storage battery. If the storage battery does not show a reading, the secondary winding is open. If the sec-

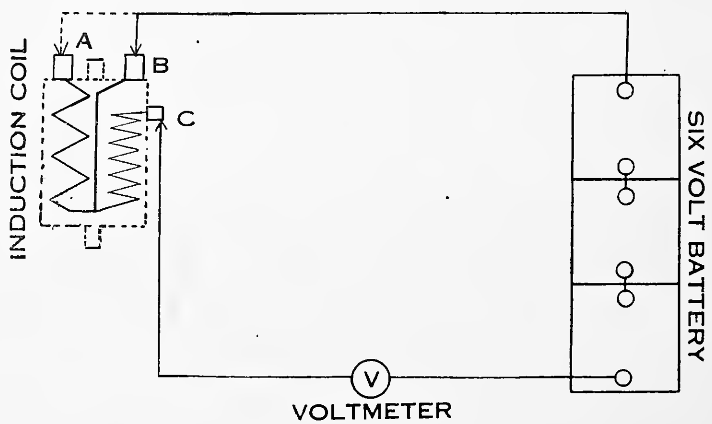


FIG. 46

ondary is all right, the voltmeter should show a reading of about half the voltage of the battery, or three volts.

Figure 46. This shows the same test as in Figure 45, excepting that the primary and secondary of the induction coil are connected together in the construction of the coil.

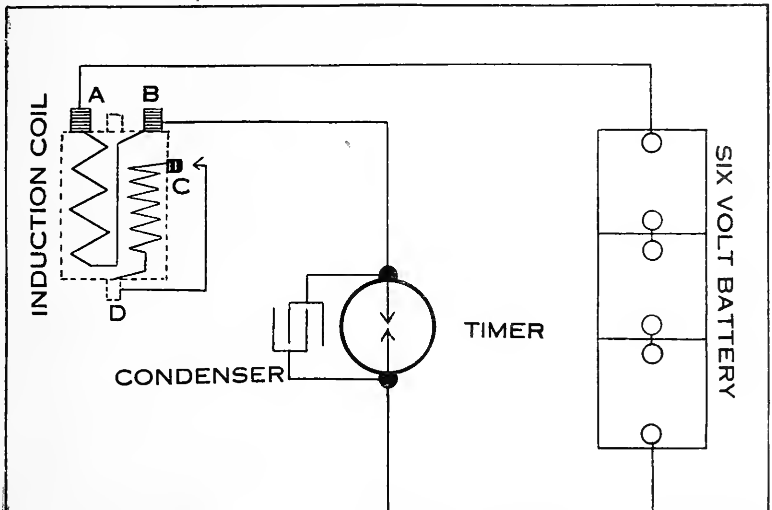


FIG. 47

Figure 47. This shows a standard battery ignition circuit using a timer. Note that the condenser is connected across the timer contacts. By making and breaking the primary circuit at the timer contacts and connecting a piece of wire to the secondary terminals of the coil, as shown, a spark should be produced at the terminals of the secondary. Always be sure to have a condenser connected across the

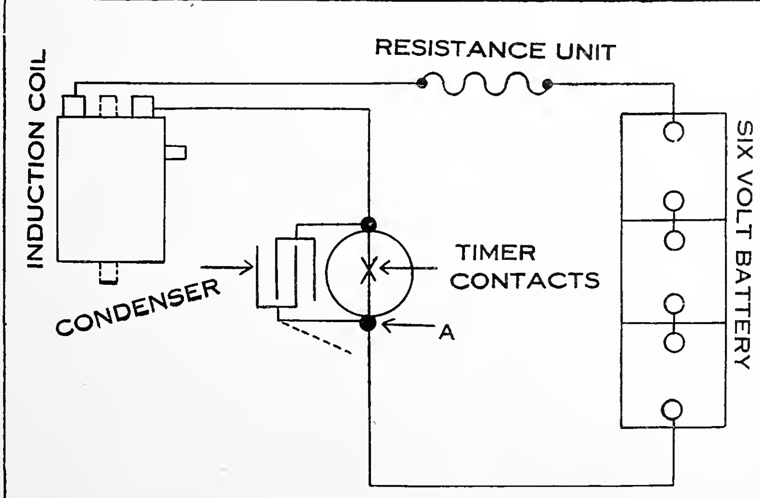


FIG. 48

point where the circuit is broken when making these tests. Each time the timer is in operation and the contacts open, a spark should occur at the terminals of the secondary. Have a one-fourth inch gap between the secondary terminals and the wire.

Figure 48. This shows the same circuit as in Figure 47, excepting that a resistance unit is connected in the circuit. A resistance unit is used in nearly all battery or generator ignition systems. It serves to regulate the flow of current used for ignition and protects the coil if switch is left on and the engine is not running.

To test the condenser, first make and break the circuit with the timer, and note the sparking at the timer contacts. Then disconnect one side of the condenser and hold this connection away, as shown by the dotted line. Now make and break the circuit with the timer and note the sparking at the timer contacts. If the condenser is good there should be considerable difference in the sparking at the inner contacts when the condenser is connected and when it is not connected.

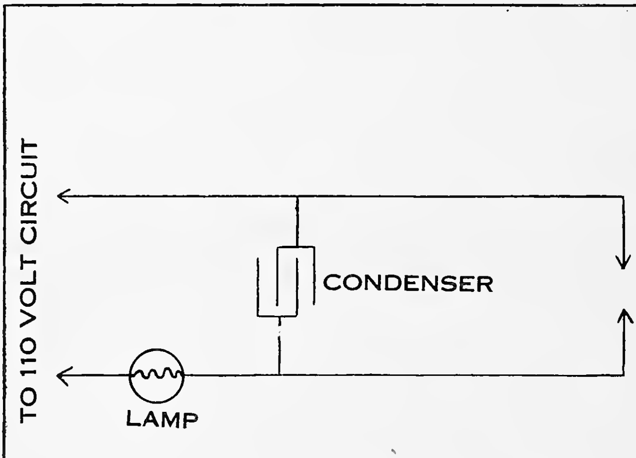
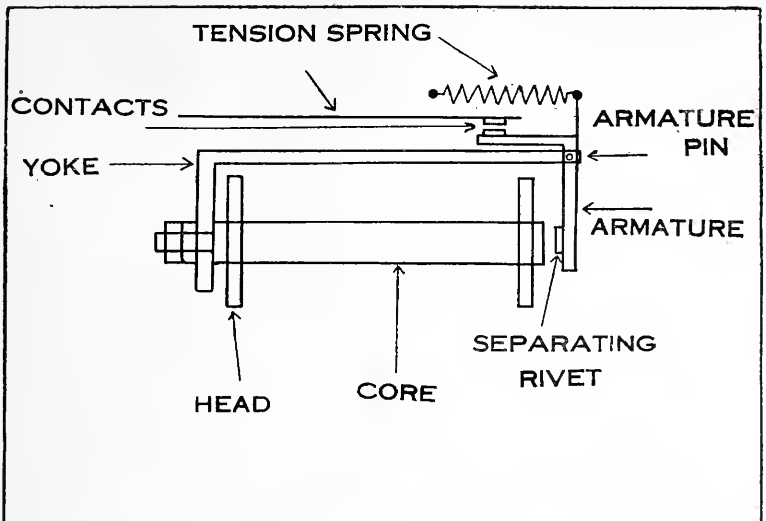


FIG. 49

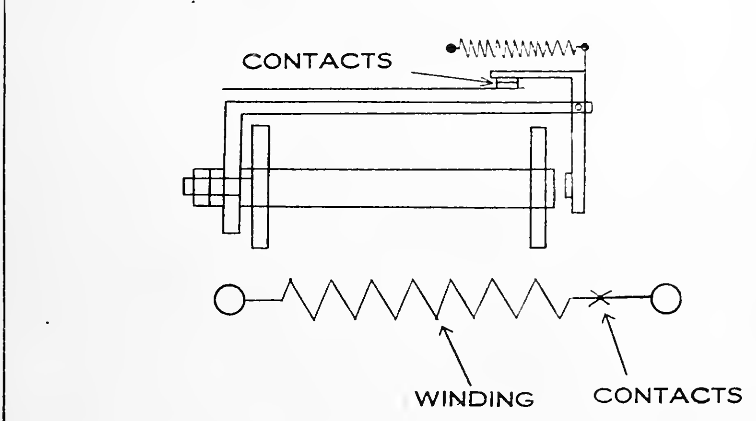
Figure 49. This shows another method of testing a condenser. If the lamp burns with the wires at "A" held apart, the condenser is short-circuited. If the lamp does not burn, the condenser is not short-circuited, but it may be open-circuited. To determine this, momentarily bring the ends of the test wires at "A" together. If the condenser is good, the spark obtained will be snapping and similar to that obtained when a wire is connected across the terminals of a storage battery, although much less in volume. If such a spark is not obtained, the condenser is defective. It would be well to compare the resultant spark obtained at the wires at "A" with and without the condenser in the circuit. There should be considerable difference in the quality of the spark. With the condenser in the circuit, the spark should be snapping and without arcing. Without the condenser in the circuit, an arc should be noted.

Figure 50. This shows the frame of the cut-out relay. In many cases the separating rivet was filed off. This rivet is there to prevent the armature from touching the iron core. The rivet is either made of German silver, brass, or copper. These metals are not affected by magnetism.

If the armature should touch the iron core it would form a complete magnetic circuit, which might cause the relay to be slow in opening or it might not open at all. Note that all parts of the relay are given names in diagram.



CUT OUT RELAY FIG. 50



CIRCUIT BREAKING RELAY FIG. 51

Figure 51. This shows the frame, contact, and armature arrangement and the circuit of a standard vibrating circuit-breaking relay. A circuit-breaking relay is so constructed and adjusted that when over a certain amount of current flows through it it will vibrate. It takes the place of fuses.

Figure 52. This shows a circuit-breaking relay in a headlight circuit, and a fuse in another headlight circuit. If an overload, or more than 10 amperes, passes through the fuse, it will blow and open the circuit, and must be replaced with a new one. The circuit-breaking relay is set so as to start vibrating when over a

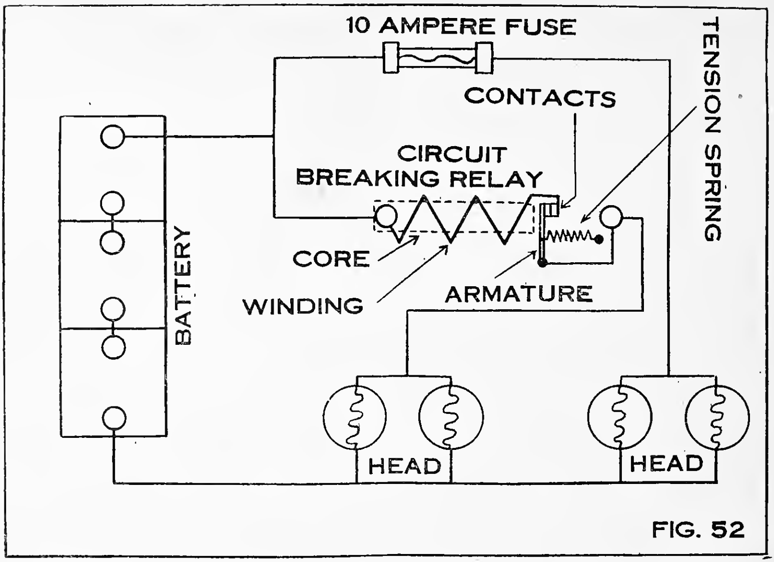


FIG. 52

certain amount of current is taken through it. It will vibrate until the current is turned off or the amount of current flowing through it is back to the amount it is set for. The circuit-breaking relay acts as an automatic fuse.

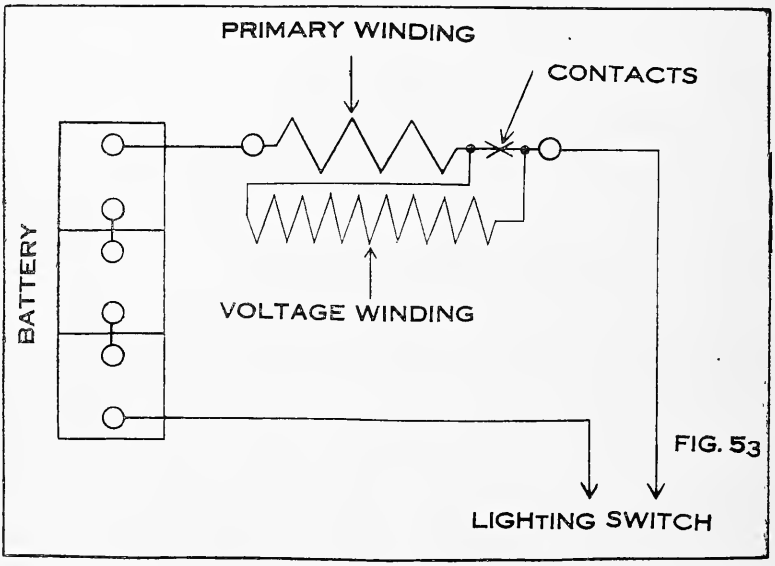


FIG. 53

Figure 53. This shows the circuit of a lockout circuit-breaking relay. Note that there as two windings, a primary and a holding coil. The contacts are in a closed position.

Figure 54. This shows the same circuits as shown in Figure 53, excepting that the relay contacts are open. When an overload is put on the relay, the armature must pull toward the core of the relay, this opening the contacts. Before the contacts are opened, current flows only through the primary.

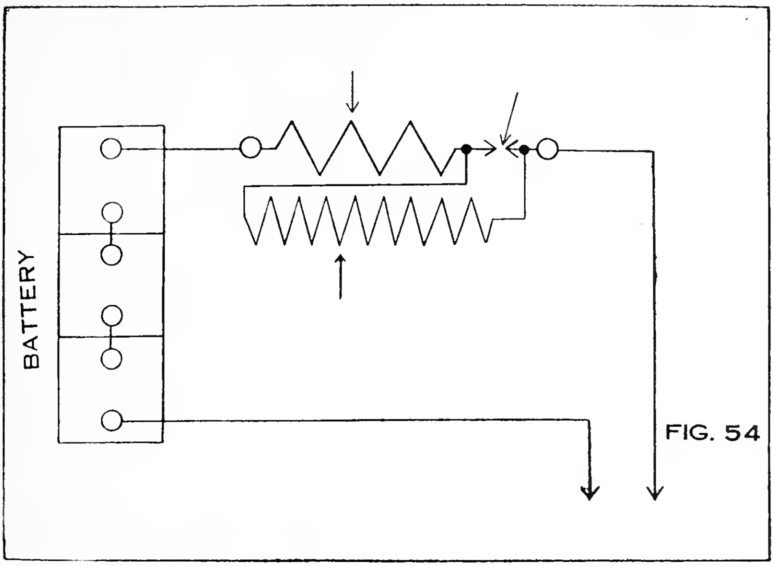


FIG. 54

When the contacts open, current flows through both windings, which causes the contacts to be held open. They will remain open until current is cut off, when the armature will be released and the contacts will go back together again, and will remain so until an excessive amount of current attempts to flow through the relay again.

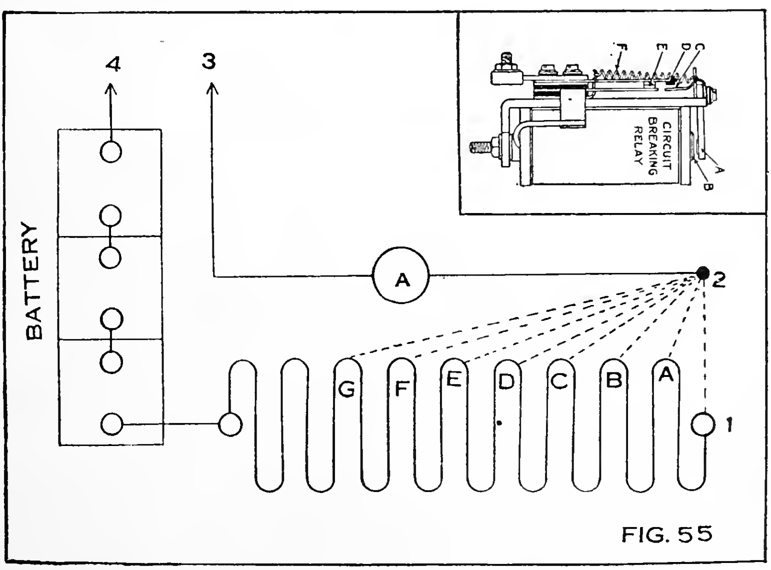


FIG. 55

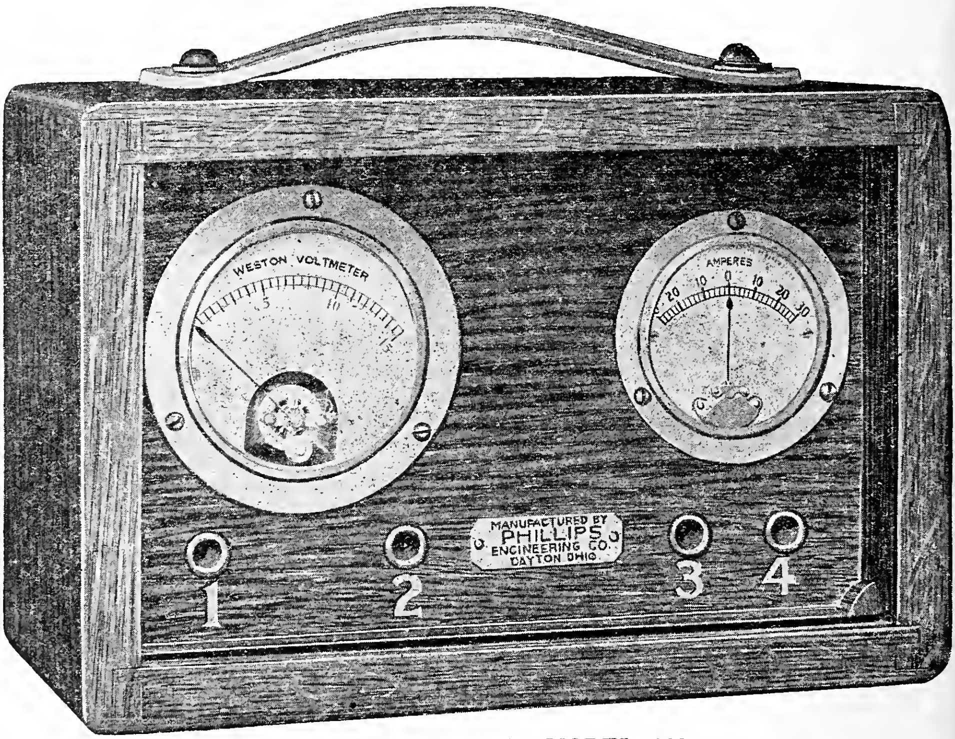
Figure 55. This shows a storage battery, resistance unit, ammeter, and wires to be connected to the terminals of a circuit-breaking relay. To make the resistance unit, secure about 30 feet of No. 16 soft iron wire. Wind it in the form of a spiral spring, and then stretch the spring until, when released, the coils of the spring do not touch each other.

To set the relay to break the circuit when a given amount of current flows through it, proceed as follows: Be sure that there are no connections between terminals 1 and 2, or from terminal 2 to the resistance unit. Then connect wires 3 and 4 to relay. Now connect a wire to terminal 2. Then touch the other end of this wire to terminal 1 and note the reading of the ammeter.

Less than ten amperes will flow. Now touch the wire that is connected to terminal 2 to the coils of the resistance unit, as shown at "A," "B," "C," and so on, watching the ammeter each time contact is made. If the relay is to be set to break the circuit at 15 amperes, watch the ammeter until a point on the resistance unit is touched when that amount is flowing.

If the relay has a tendency to break the circuit before 15 amperes is reached, the tension spring should be stiffened. If the relay does not open at 16 amperes, the tension spring should be weakened until the contacts will open. Then test again in the same way.

Do not attach wires from 2 terminal to the resistance unit at any point. Only touch it to the resistance wire long enough to get a reading.



PHILLIPS TEST SET MODEL 302

Your garage or Service Station is not complete without a reliable electric testing instrument. We believe that our instruments are the best to be had at any price.

We are pleased to refer you to the service manager of any motor car manufacturer in America.

Standard set as shown in cut above $25.00. Special set with voltmeter reading from 0 to 15 volts and 0 to 150 volts with same ammeter, cords and instruction book, $30.00.

STANDARD MODEL 302

This is a new design and is very small and compact. The cabinet is made of oak. Size of cabinet is 9x6x4 inches.

The voltmeter reads from 0 to 15 volts and the ammeter reads from 0 to 30 amperes either way, being known as the center zero type. One pair of No. 10 test cords and special picture instruction book are supplied with each set. No service station or garage is complete without this instrument. No danger of injuring the instruments if wrong connections are made in testing automobile electric systems. If the user allows the ammeter to remain in a circuit too long where the drain on the battery is above the scale reading, the attachment cords may be burned up. In this case it will cost $2.00 for a new pair.

PHILLIPS ENGINEERING COMPANY,
Dayton, Ohio.

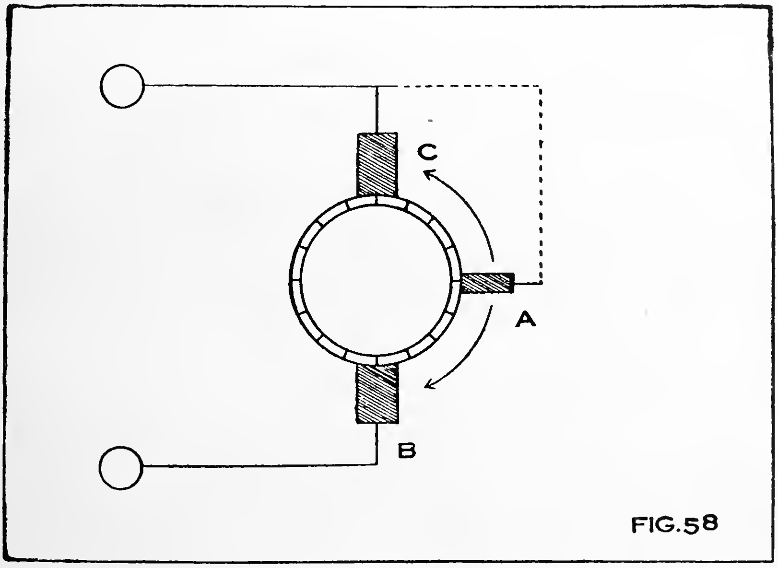


Figure 58. Method of increasing or decreasing the output of a generator employing third brush regulation. Dotted line represents the field coil circuit. To increase the output of the generator, move brush "A" toward brush "B." To decrease output of the generator, move brush "A" toward brush "C."

Figure 59. This shows top view of a cut-out relay with primary terminals numbered 1 and 2. No. 3 is the frame or one end of the voltage winding of the relay. To find the terminal that the other end of the voltage winding is connected to, use a pair of test cords with a lamp in the circuit. Use 110 volts. Touch one end of test cord to frame of relay and the other end to terminal 1, and then to terminal 2.

When terminal is touched and lamp burns or a spark is produced, this is the other end of the fine winding. This terminal should be connected to the generator, and the other terminal, where the light would not light or no spark was produced when touched, should be connected to the storage battery.

"A" shows contact springs, "B" tension spring, "C" armature pin, and "D" is the armature.

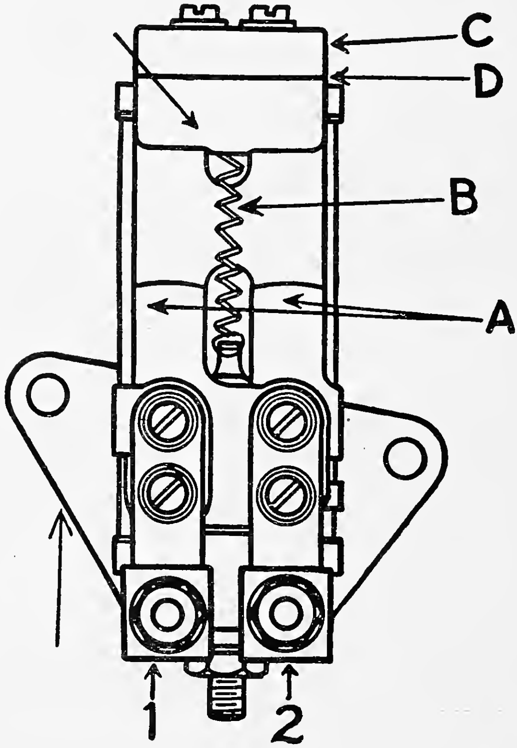


FIG. 59

Figure 60. This is used to show a hydrometer. This is the part that is in the glass barrel of a hydrometer syringe. The hydrometer is used to test the specific gravity of the electrolyte of storage batteries. Directions for using are as follows:

After removing the filling plug from the cover of the cell, compress the rubber bulb of the syringe and insert the pipette in the solution of the cell to be tested. Holding the instrument as nearly vertical as possible, gradually lessen the pressure on the bulb until the electrolyte rising in the barrel causes the hydrometer to float.

In general, only enough electrolyte should be drawn to float the hydrometer free of the bottom by about one-half to three-quarters of an inch. The specific gravity reading is taken on the hydrometer at the surface of the electrolyte in the glass barrel.

If the electrolyte is below the top of the plates, or so low that enough cannot be drawn into the barrel to allow of a proper reading of the hydrometer, fill the cell to the proper level by adding pure water; then do not take a reading until the

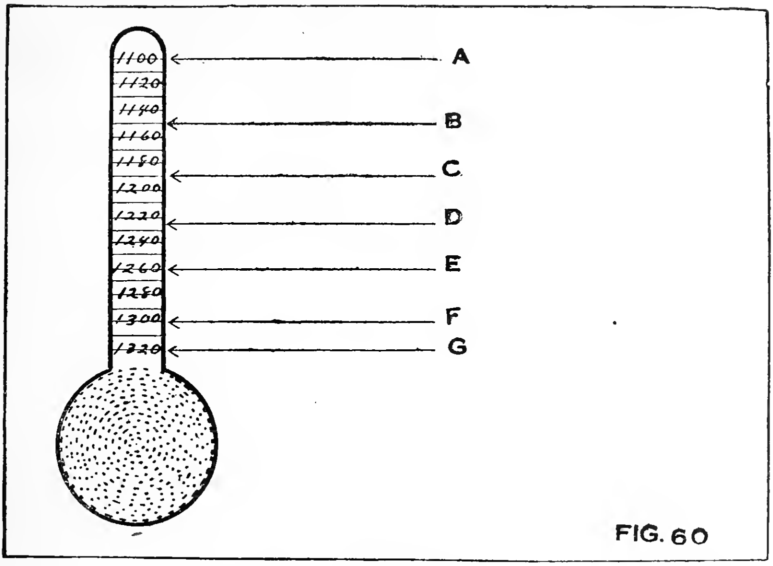


FIG. 60

water has been thoroughly mixed with the electrolyte. This can be accomplished by running the engine for several hours.

The specific gravity of the electrolyte is an indication of the amount of charge in the battery. In a fully charged battery the specific gravity should be from 1.275 to 1.300. When the gravity registers from 1.150 to 1.175, the battery is practically discharged and should be recharged.

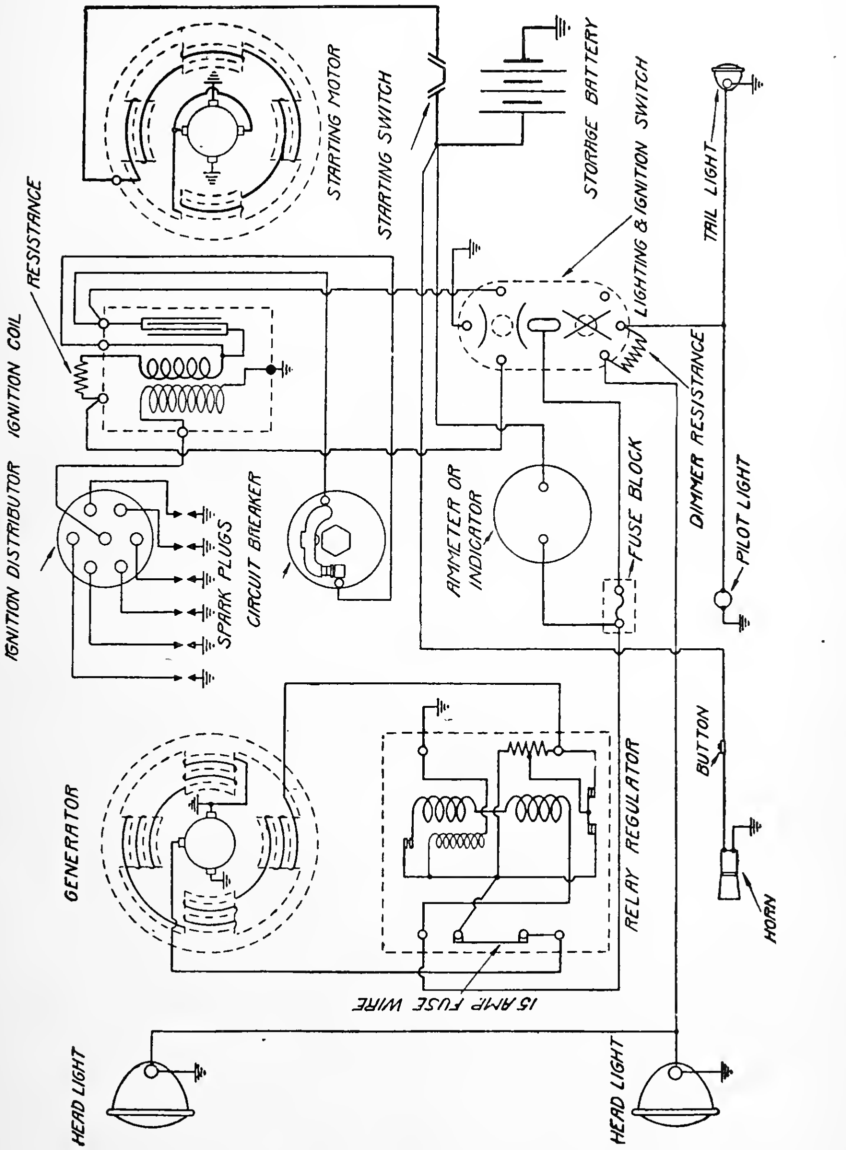
If surface of electrolyte is at "A," the gravity of the solution is 1.100. If surface of electrolyte is at "B," the gravity is 1.150. At "C" it is 1.190. At "D" it is 1.225. At "E" it is 1.260. At "F" it is 1.300. At "G" it is 1.320.

The solution should never test over 1.300, and if it does test over 1.300 it should be weakened until it is at or below 1.300 when battery is fully charged.

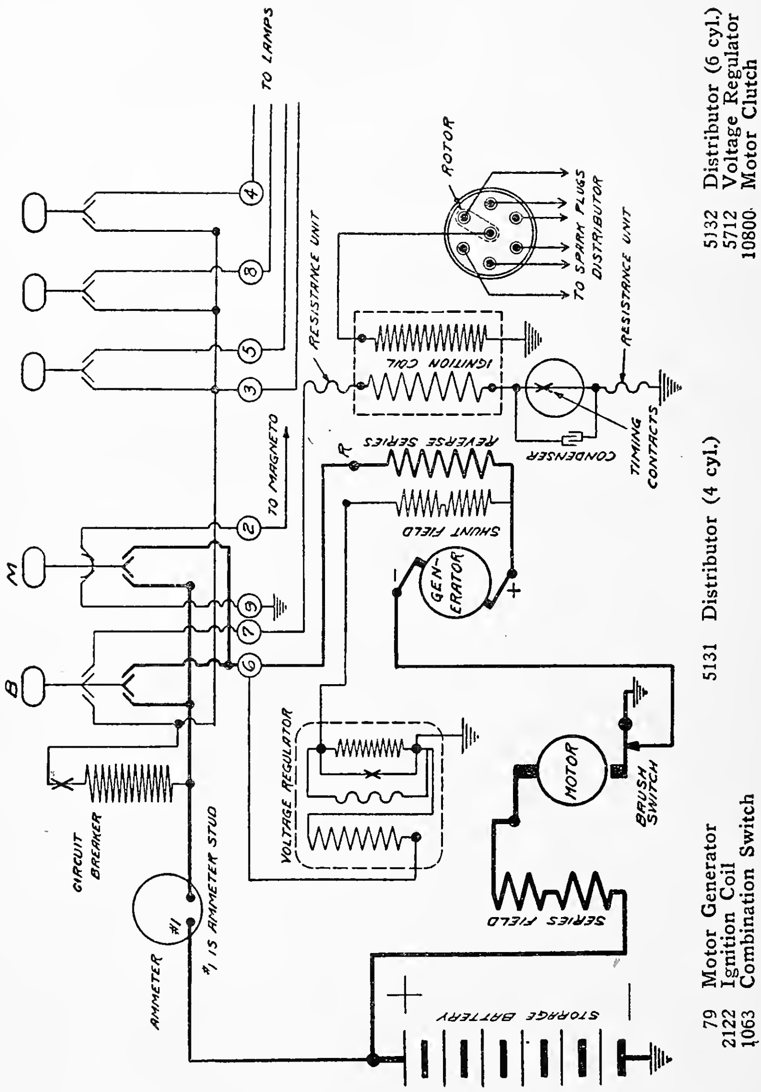
SECTION 9

1917 INTERNAL CIRCUIT AND WIRING DIAGRAMS

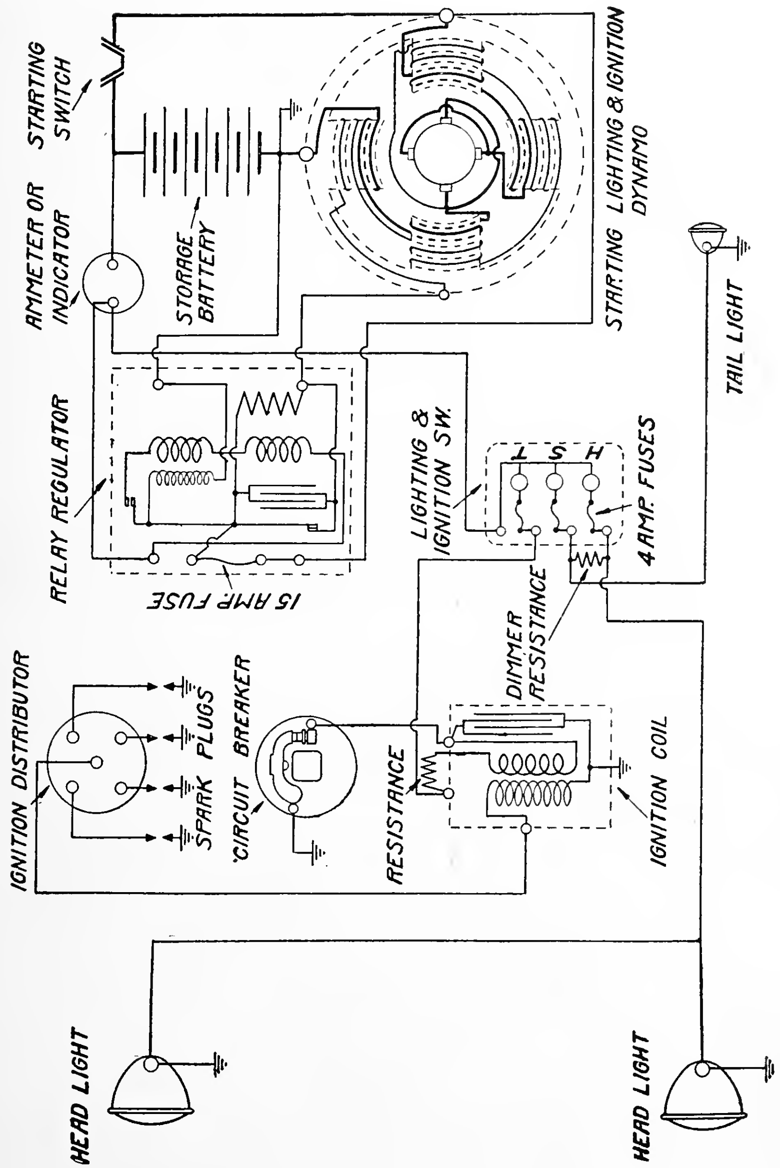
1917 Internal Circuit and Wiring Diagrams



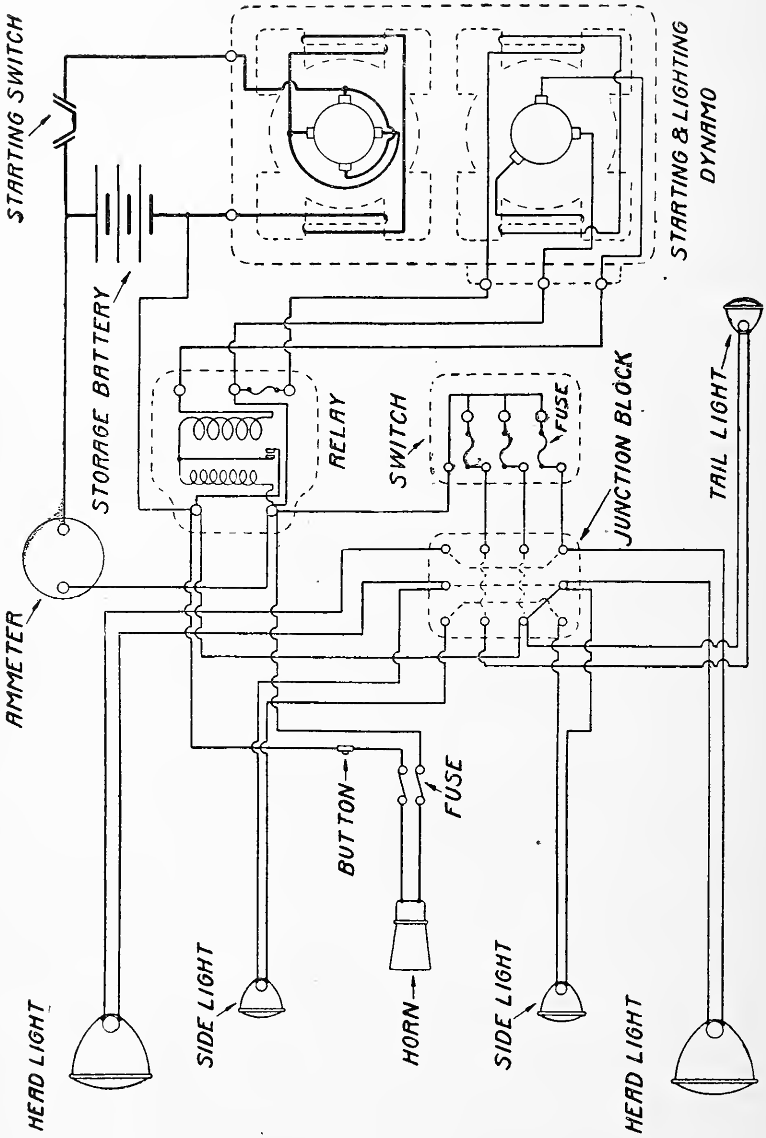
1917 Abbott Detroit—Remy System



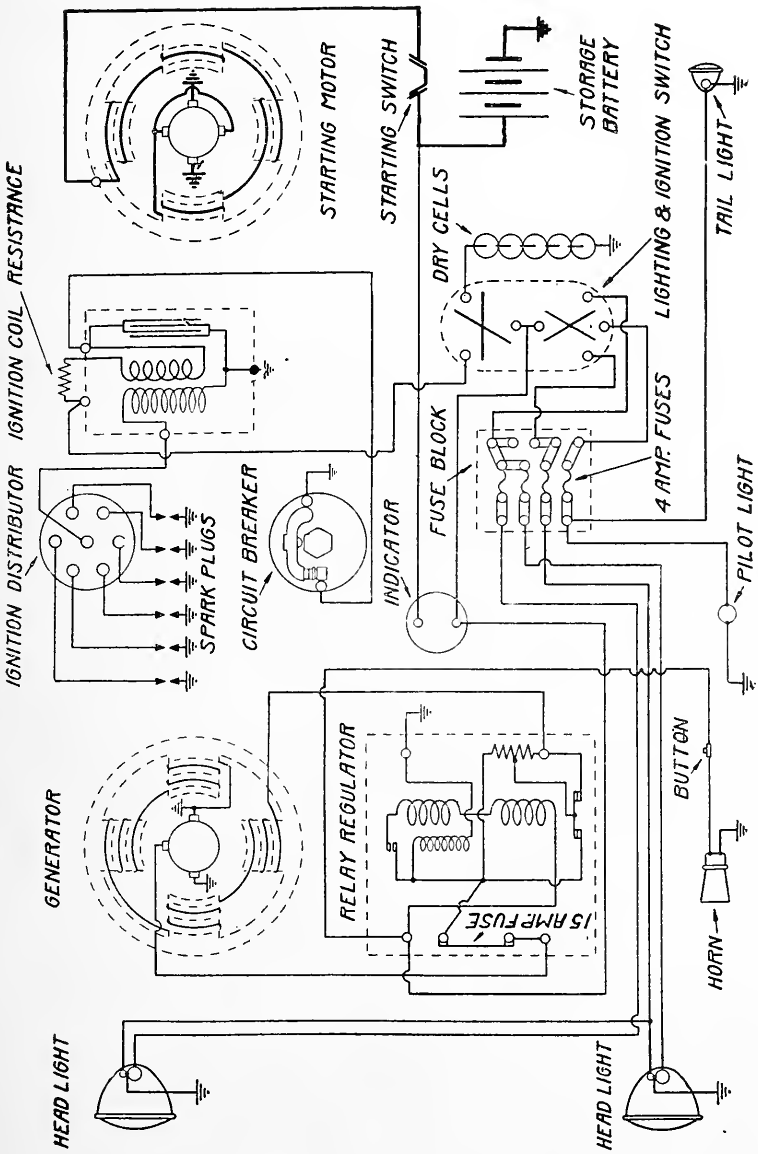
Ahrens-Fox Fire Engine Company—1917 Delco System



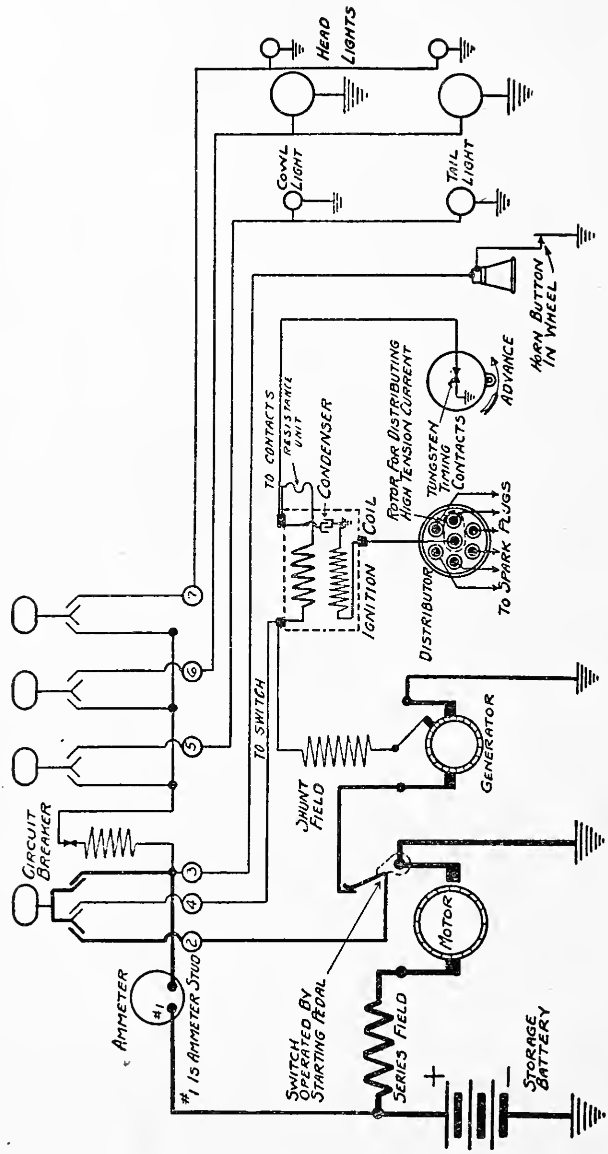
1915 Alter—Remy System



1913, 1914 and 1915 Auburn—Remy System

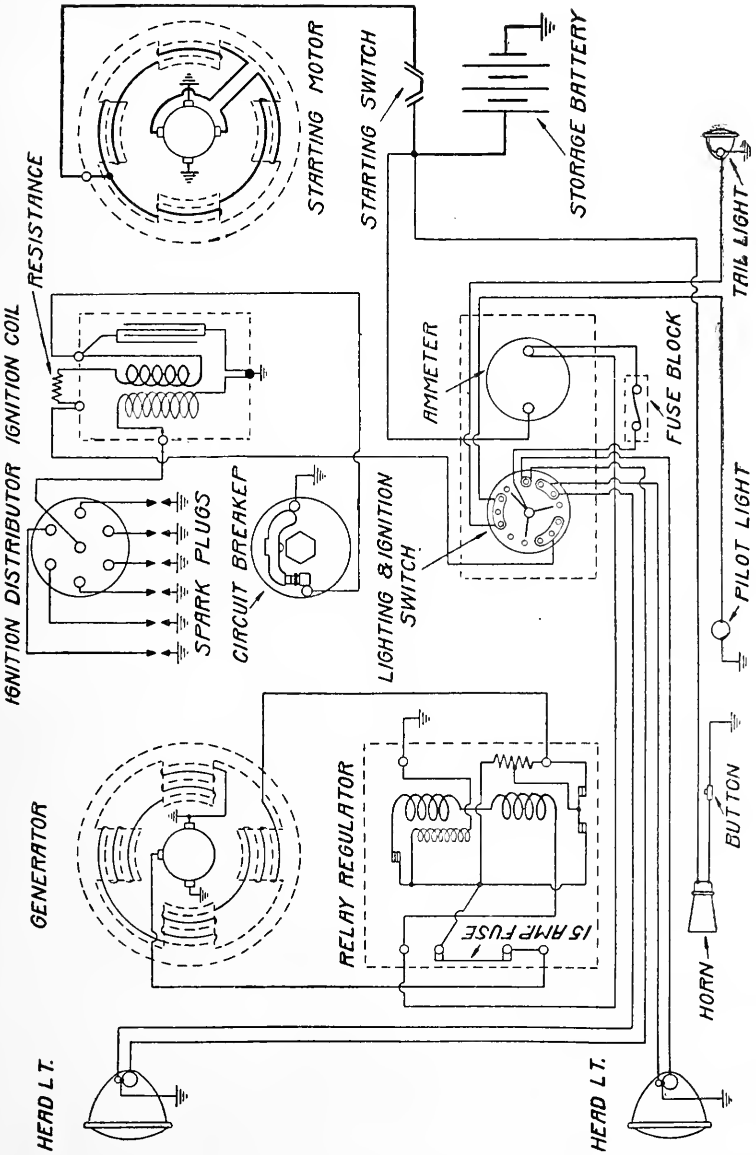


1916 Auburn, 4-38, 6-38 and 6-40—Remy System

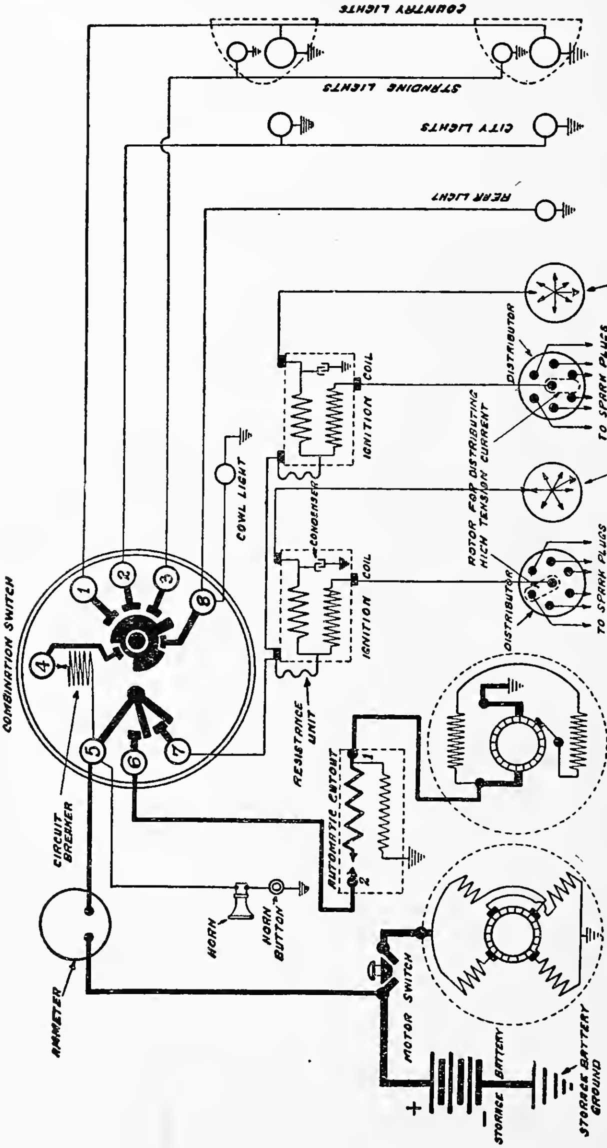


83 Motor Generator
1066 Combination Switch
2142 Ignition Coil
12225 Motor Clutch

Auburn Automobile Company—Model 6-44—1917 Delco System

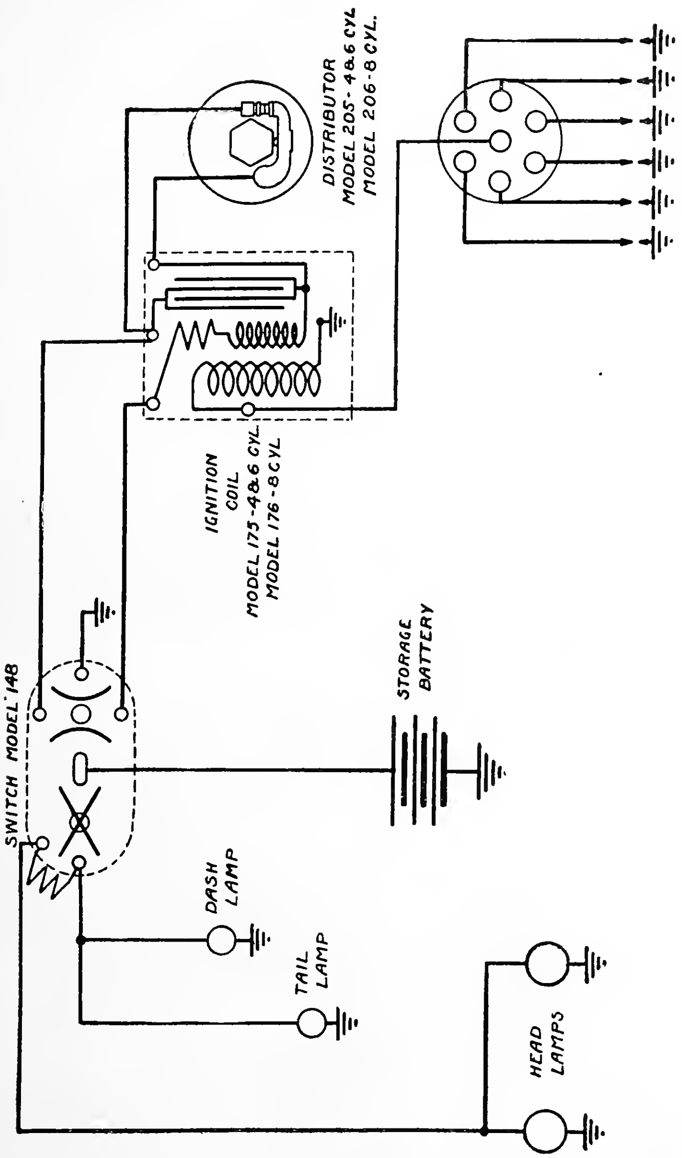


Auburn 6-39, 1917—Remy System

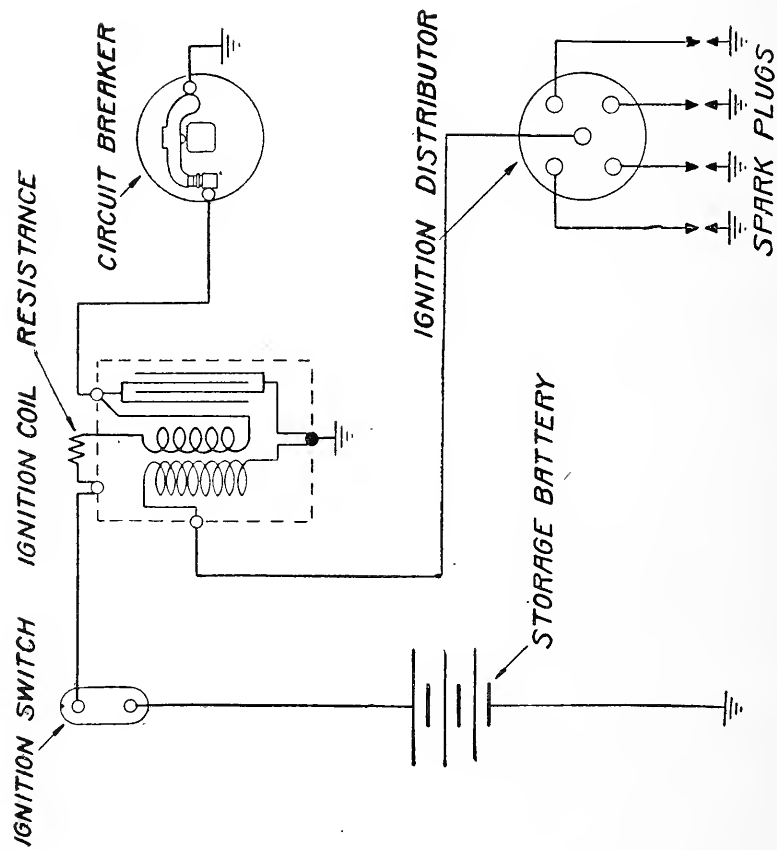


87 Generator
5715 Automatic Cut-Out
5136 Distributor
2123 Ignition Coil (2)
1085 Combination Switch
86 Motor
1965 Motor Switch
6064 Ammeter

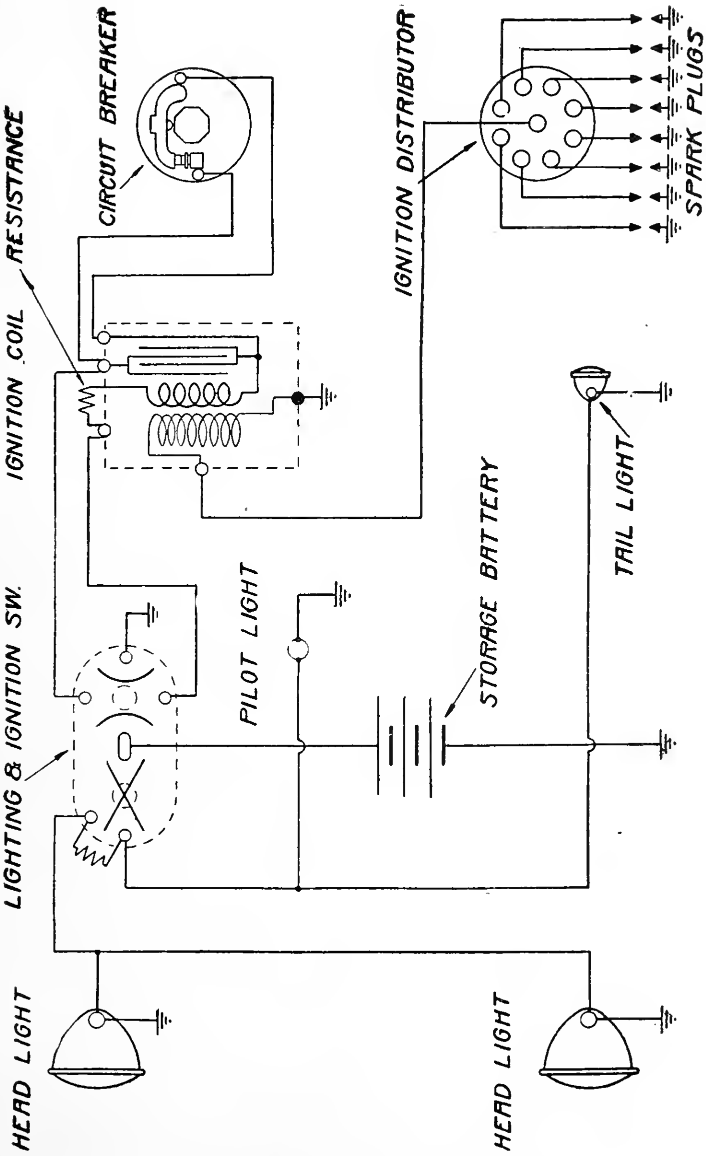
Austin Automobile Company—12 Cyl. Model—1917 Delco System



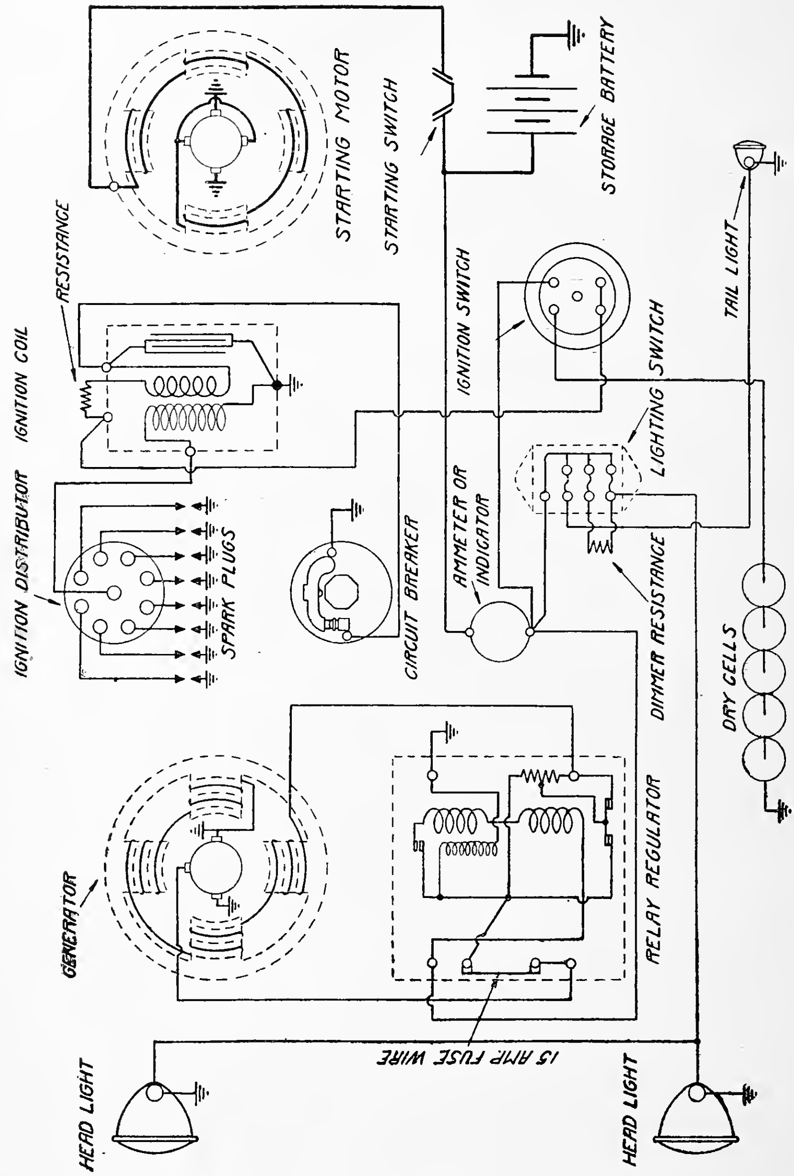
1916, 1917 and 1918 Apperson—Remy Ignition



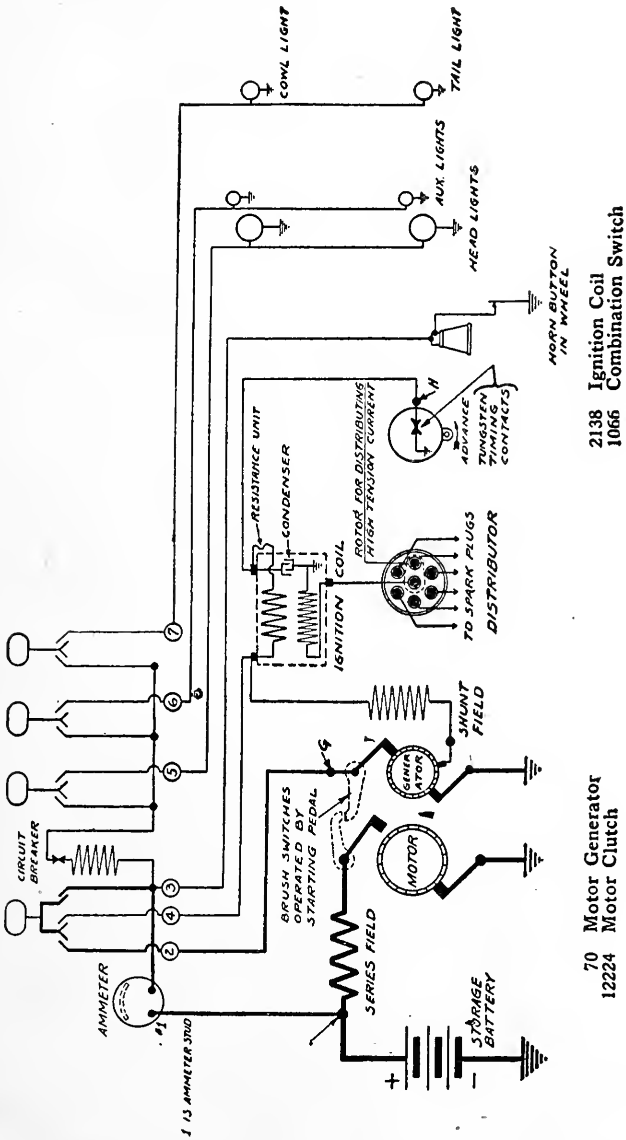
Briscoe Model 4-24—Remy Igniton



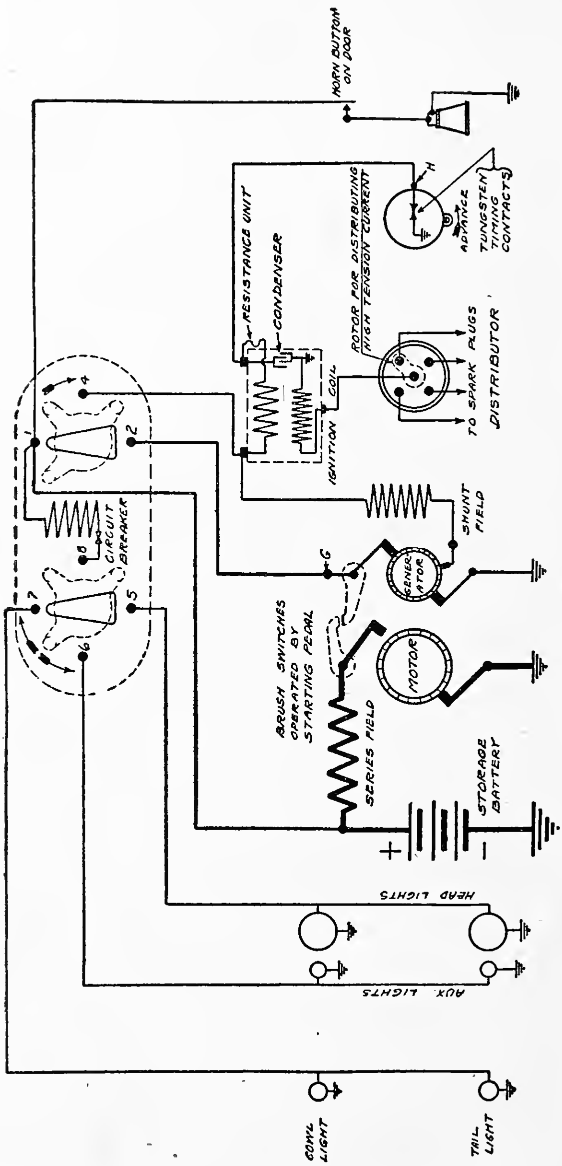
Briscoe Model 8-38—Remy Ignition



8 Cyl. Briggs Detroiter—Remy System

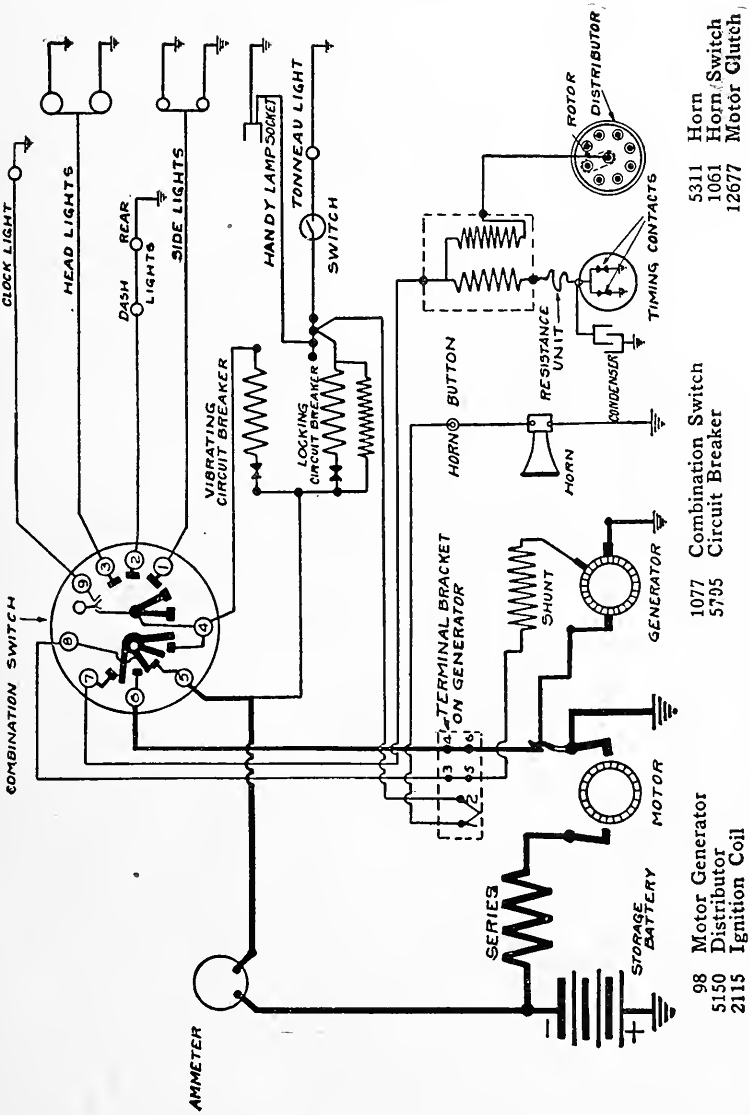


Buick Motor Company—Models D-44-45-46-47—1917 Delco System



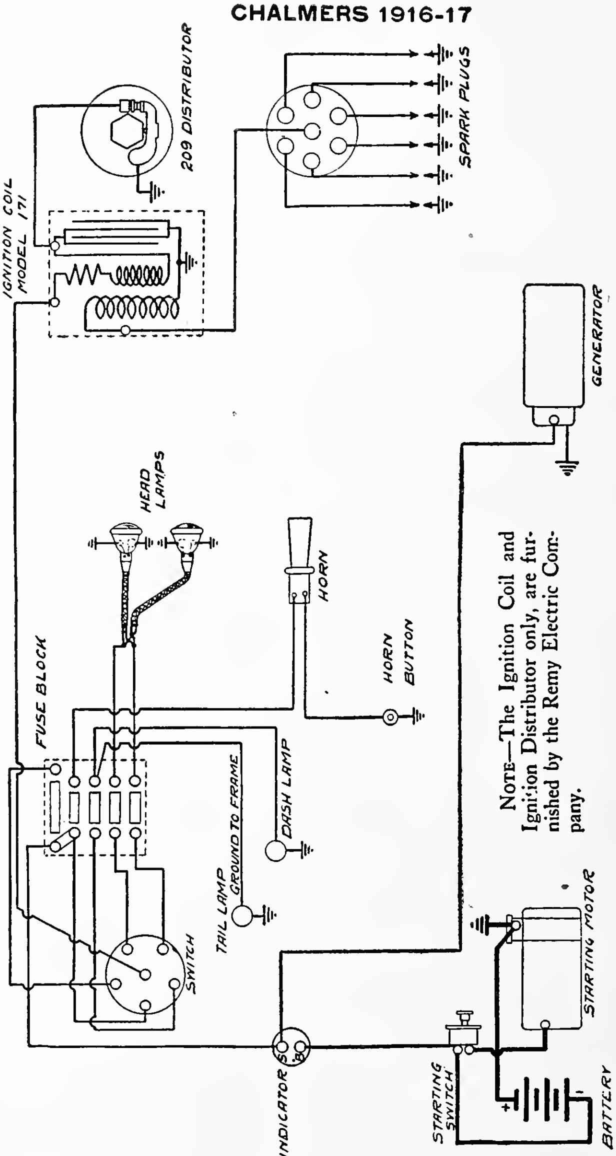
94 or 115 Motor Generator
2138 Ignition Coil
1075 Combination Switch
12647 Motor Clutch

Buick Motor Company—Models D-34-35—1917 Delco System



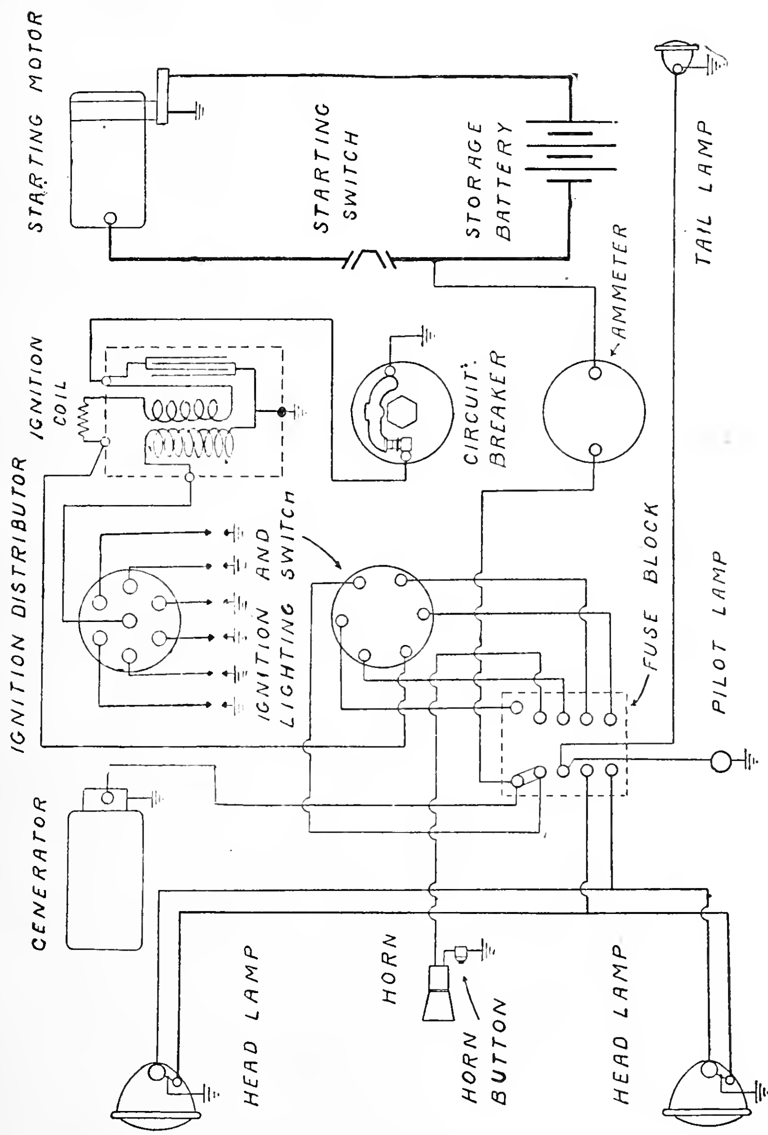
Cadillac Motor Car Company—Model 55—1917 Delco System

CHALMERS 1916-17

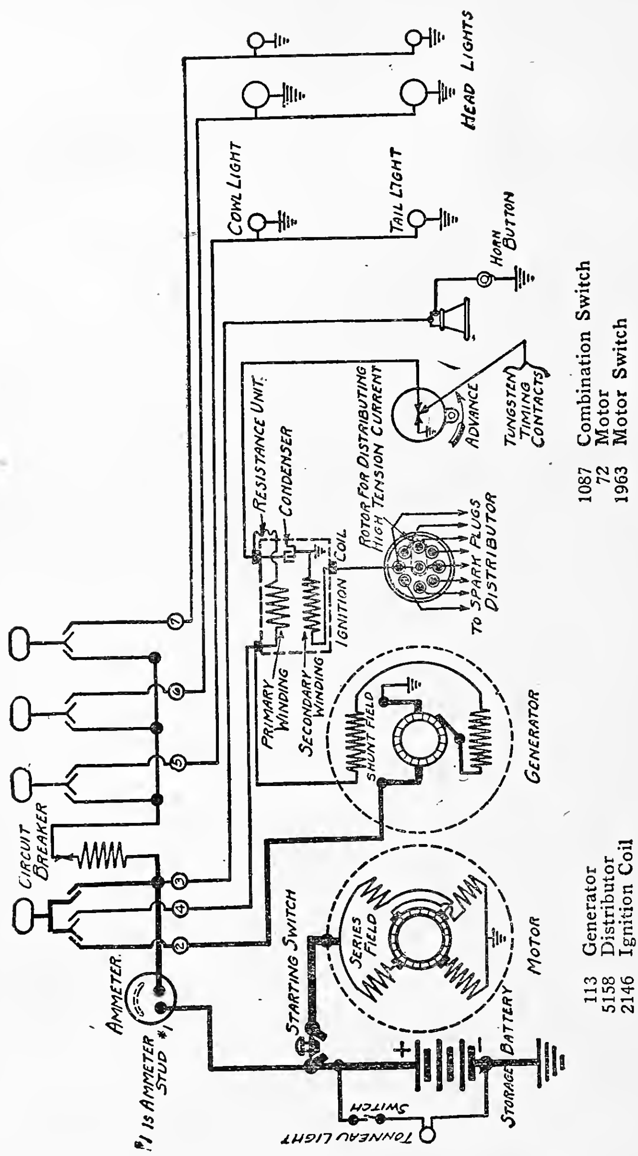


NOTE—The Ignition Coil and Ignition Distributor only, are furnished by the Remy Electric Company.

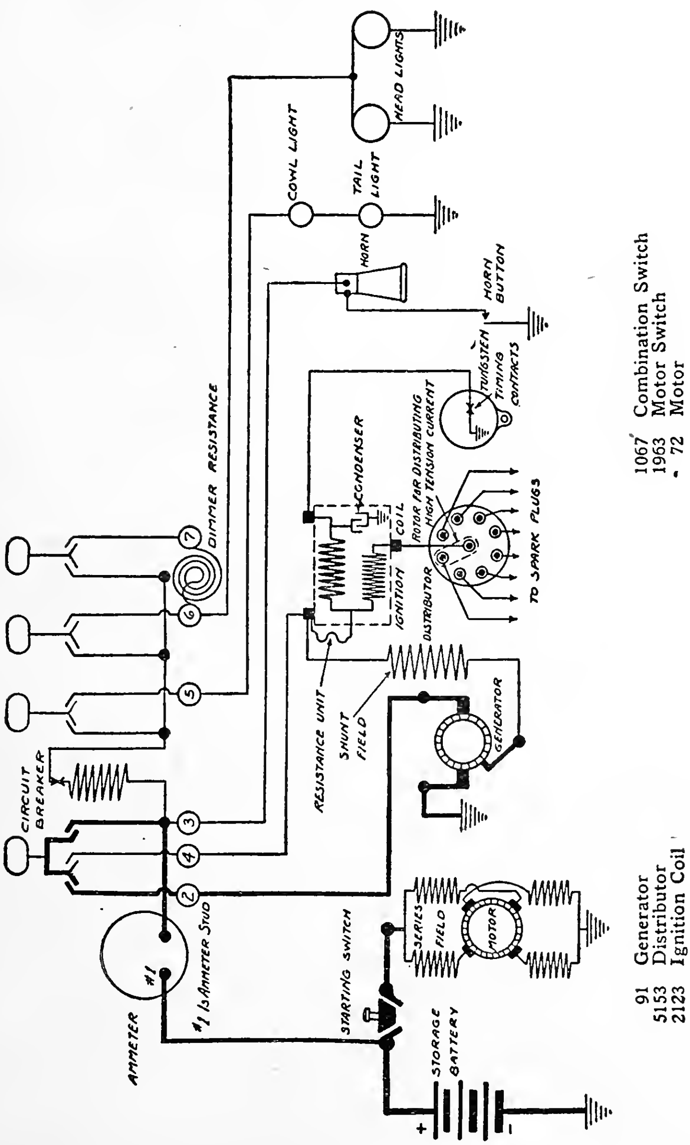
Chalmers 1916 and 1917—Ignition—Remy System



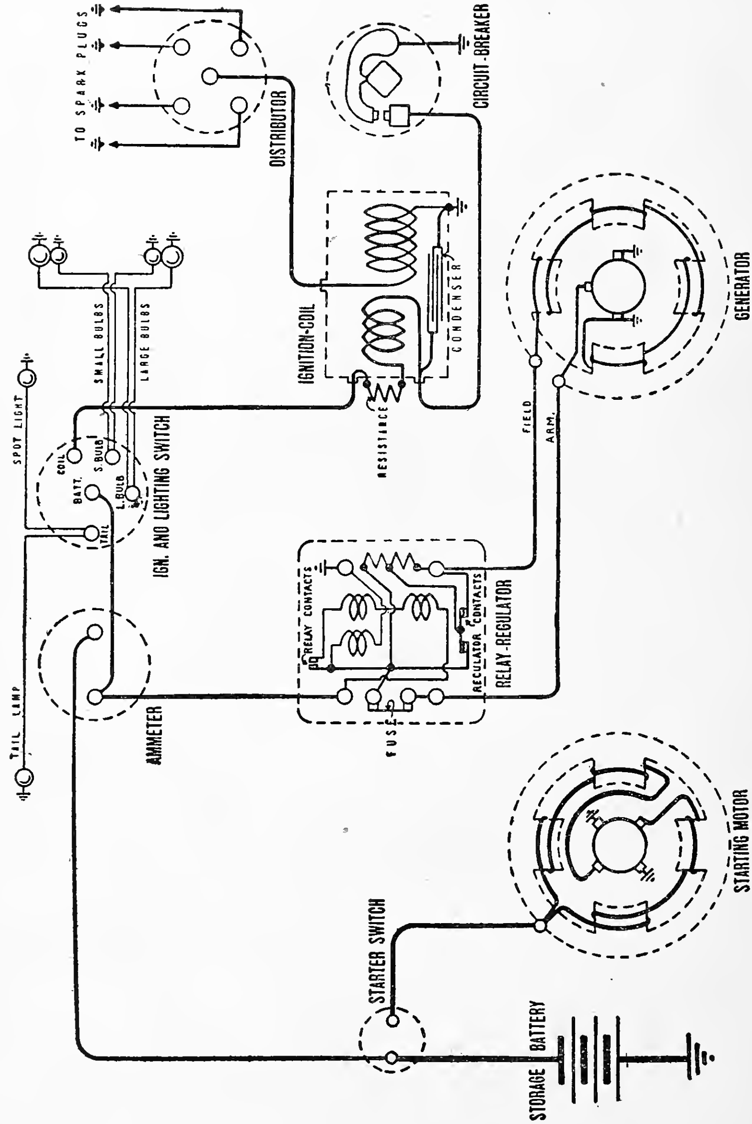
1918 Chalmers—Remy System



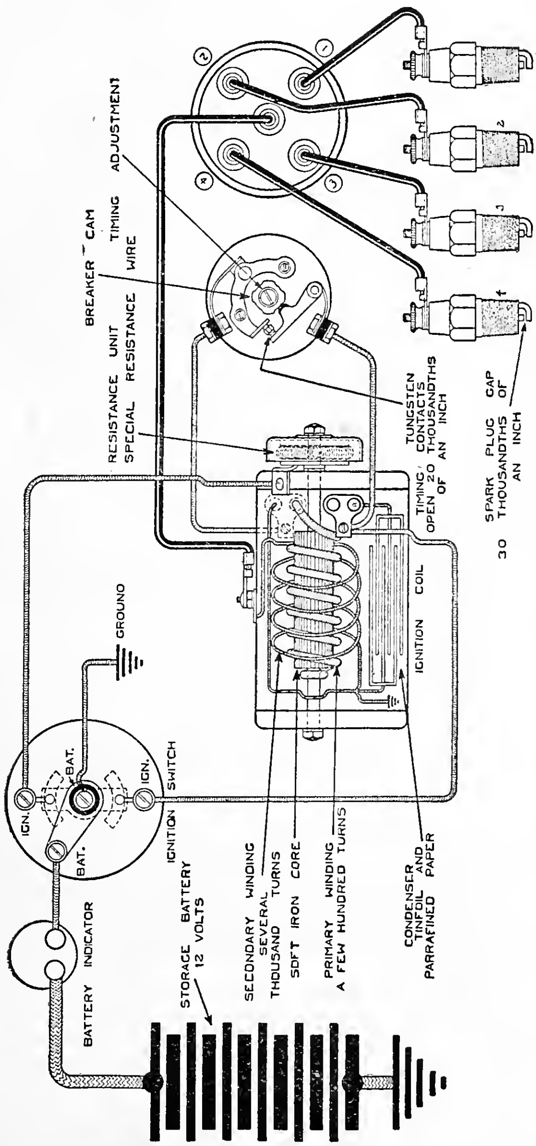
Cole Motor Car Company—Model 880—1917 Delco System



Cole Motor Car Company—Model 860—1917 Delco System

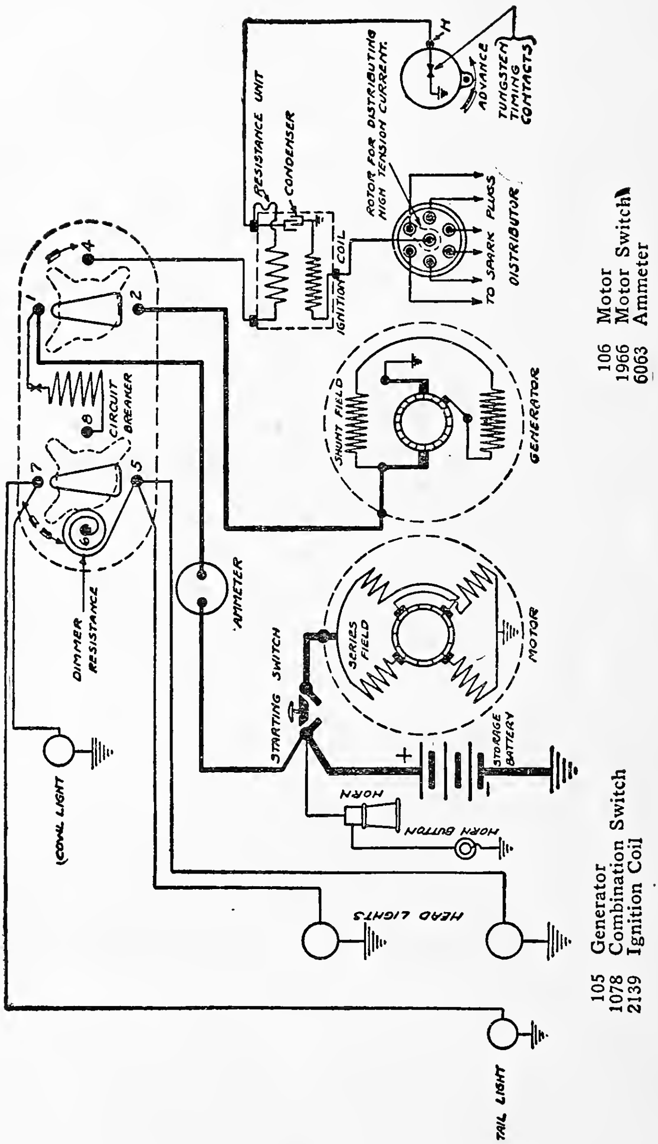


Commerce—Model E—Remy System

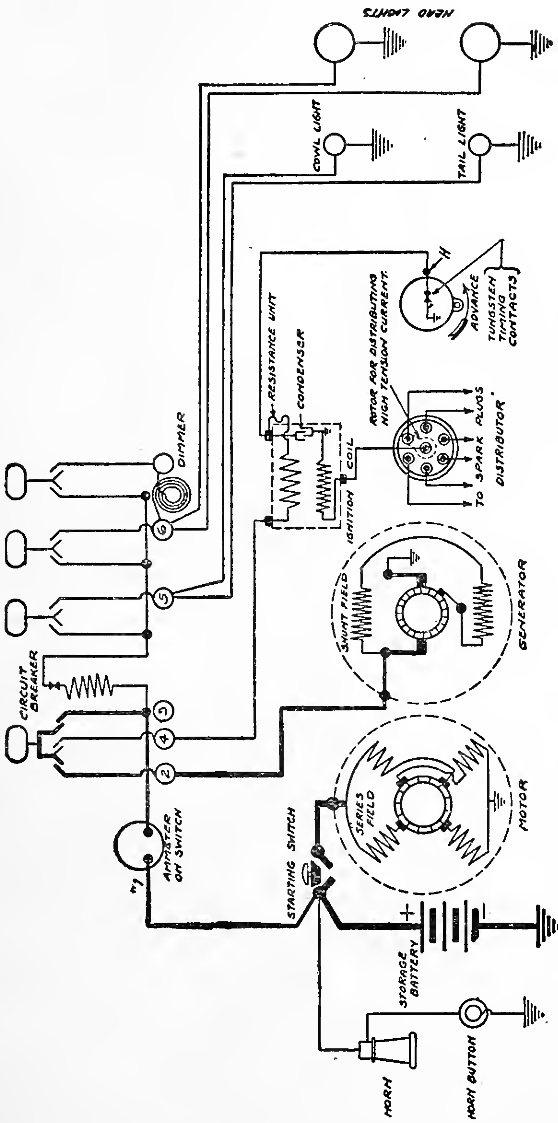


5151 Distributor, including Ignition Coil No. 2128

Dodge Brothers—1917 Delco Ignition

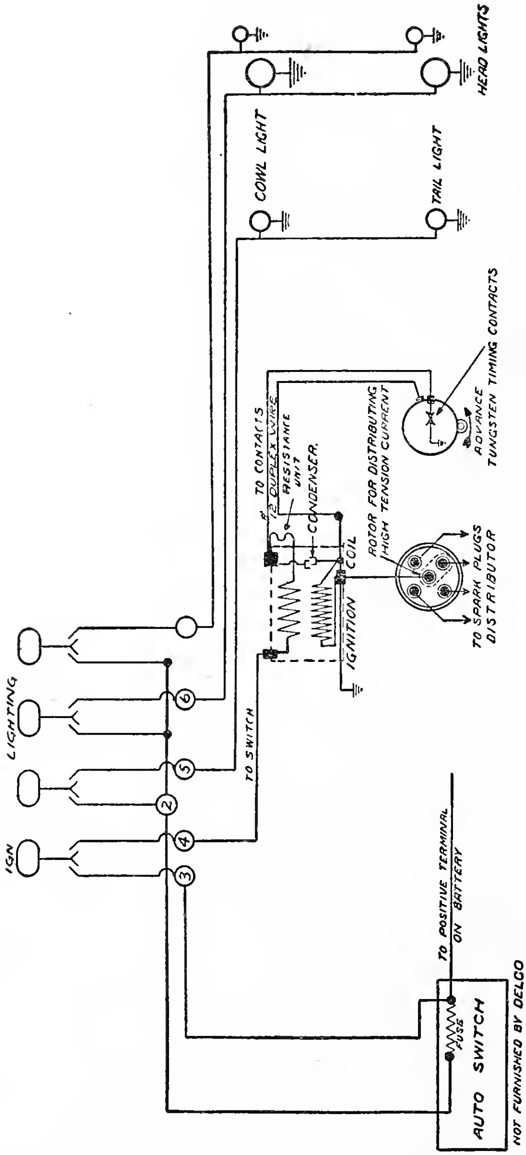


Geo. W. Davis Motor Car Co.—Models 6-H, 6-I, 6-K—1917 Delco System



114 Generator
1067 Combination Switch
2139 Ignition Coil
102 Motor
1966 Motor Switch

Geo. W. Davis Motor Car Company—Model 6-J—1917 Delco System



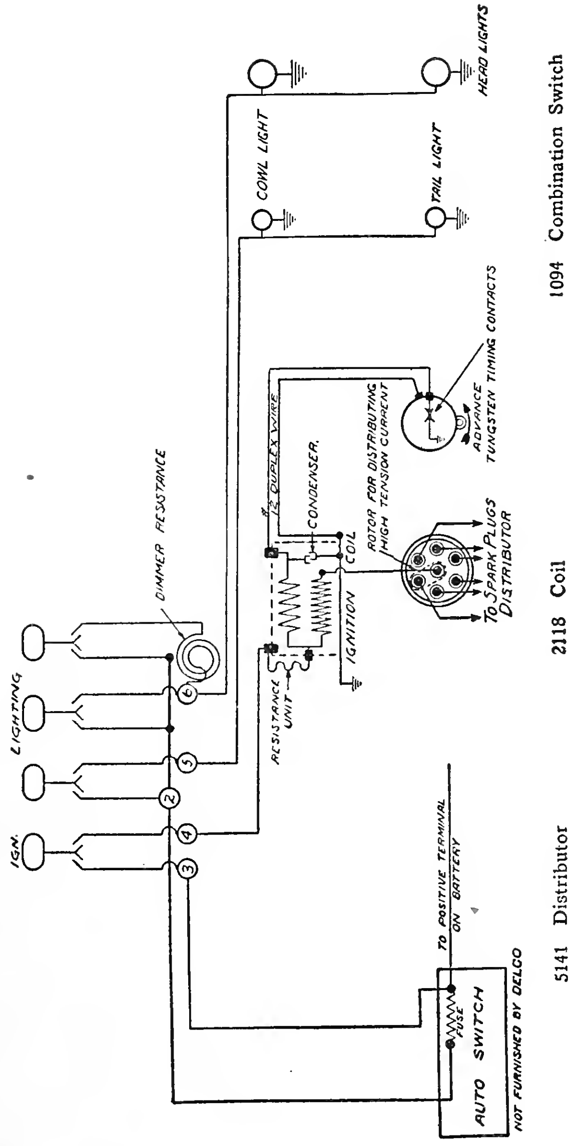
5148 Distributor

2138 Ignition Coil

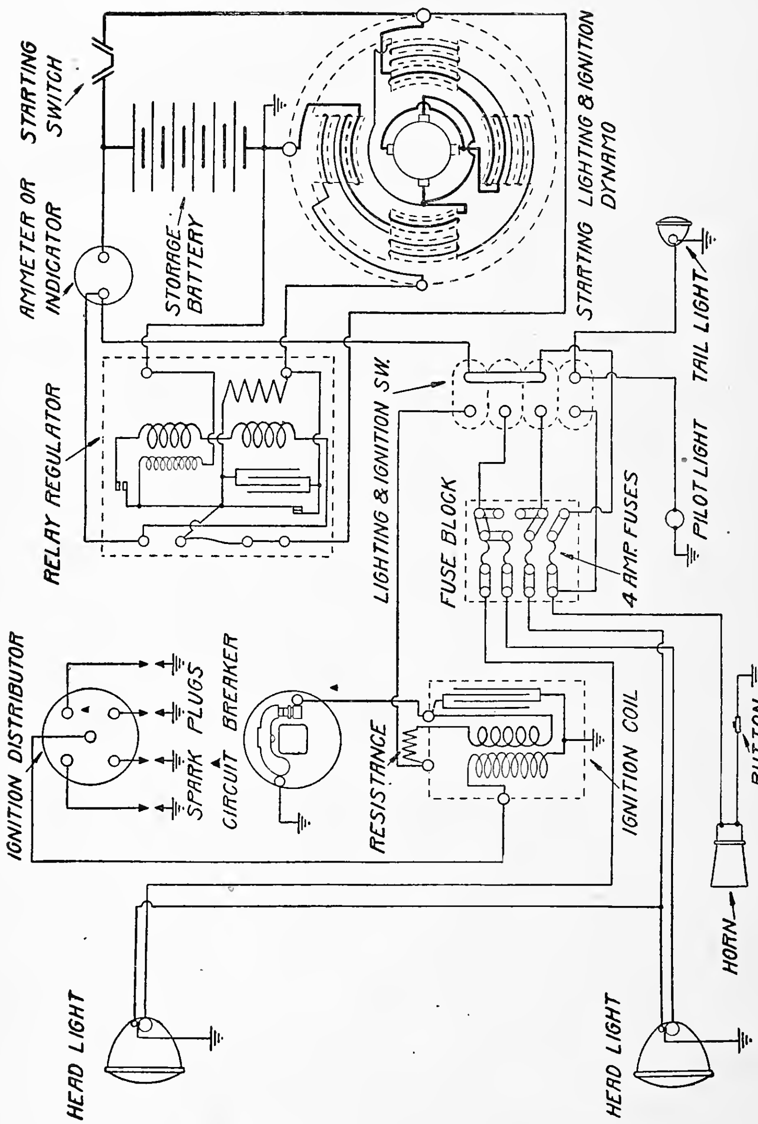
1073 Combination Switch

Note.—Six cylinder distributor is used

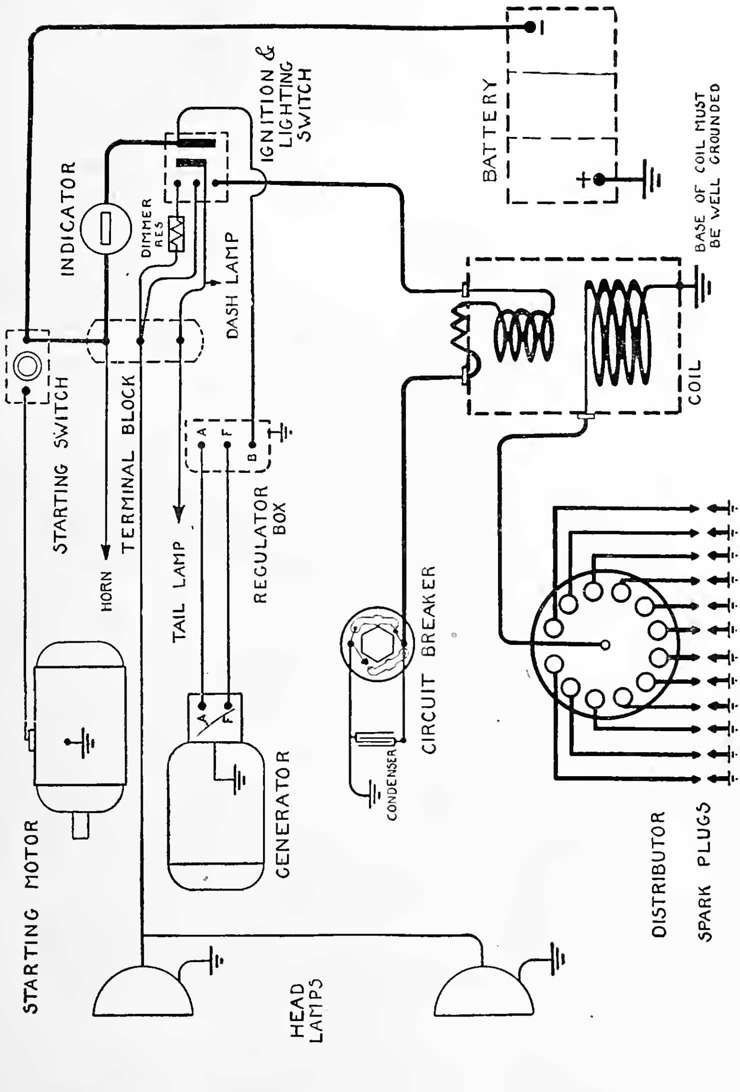
Elgin Motor Car Corporation—Model 6-E-16—1917 Delco Ignition



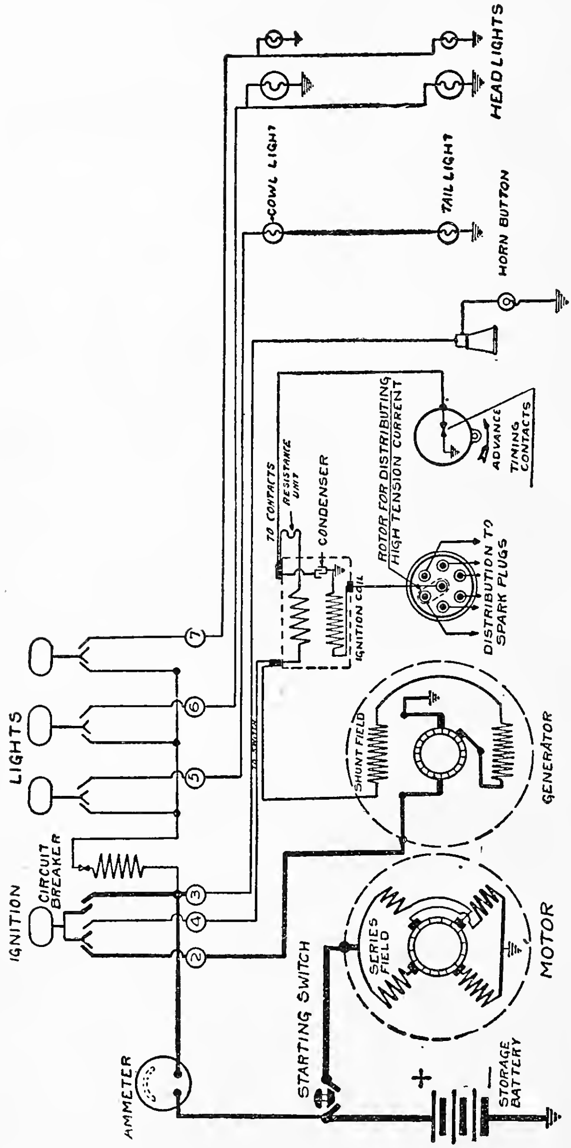
Elkhart Carriage & Motor Car Company—1917 Delco Ignition



1915 Empire—Remy System

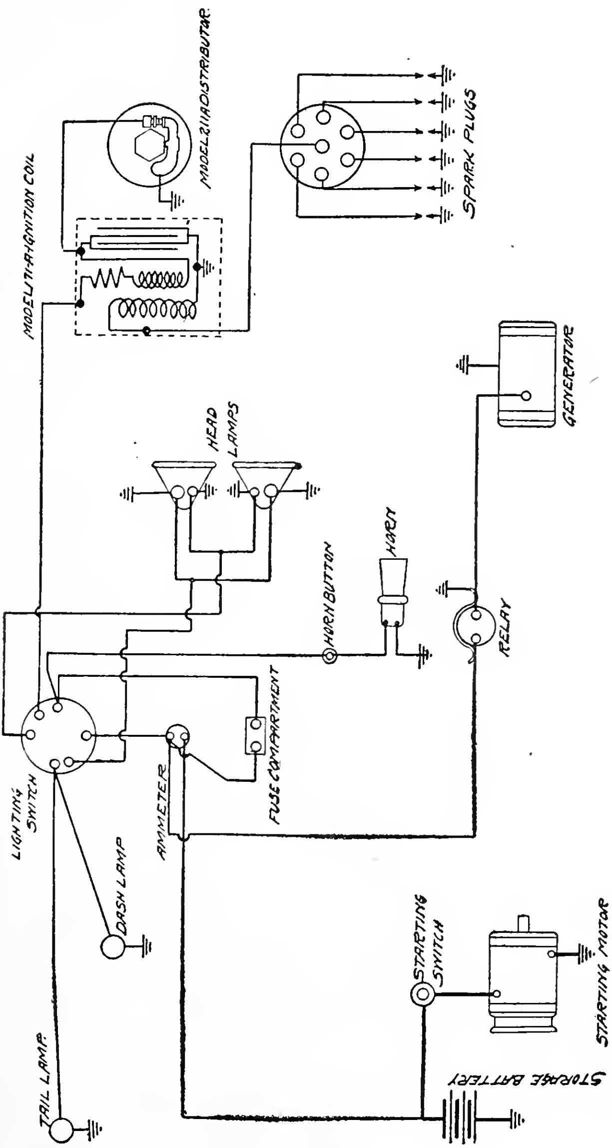


Enger 12 Cylinder—1916 and 1917—Remy System

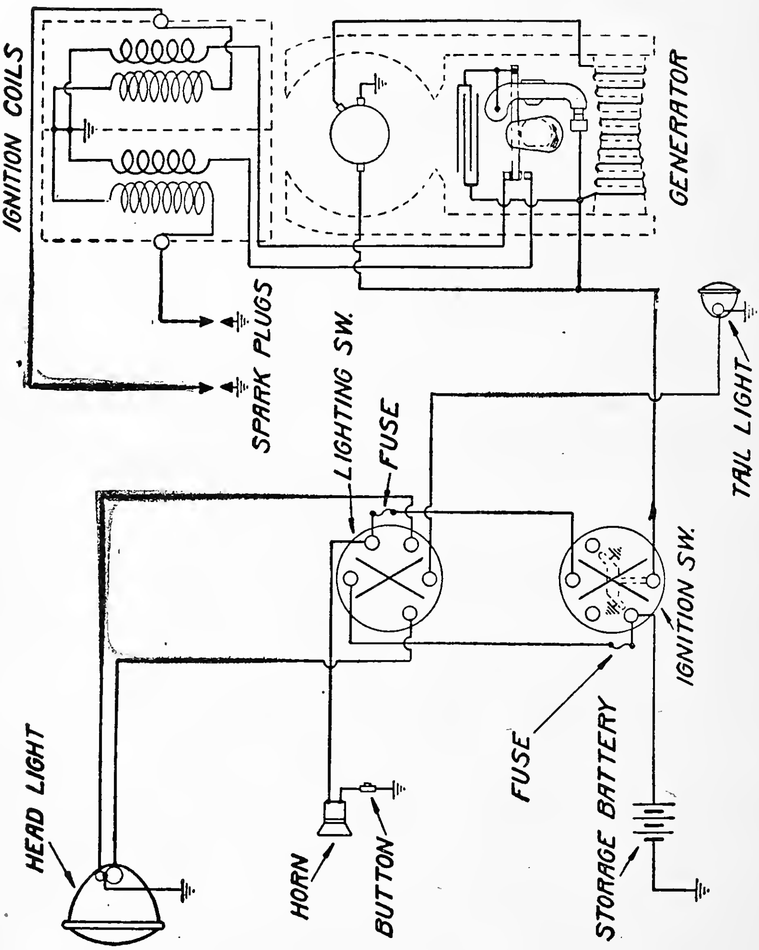


95 Generator
2134 Ignition Coil
1066 Combination Switch
1965 Motor Switch.
Models 40, 41, 70, 71, 100, 101 use No. 85 Motor
Model 15 uses No. 96 Motor
Models 25, 26, 30, 31 use No. 97 Motor

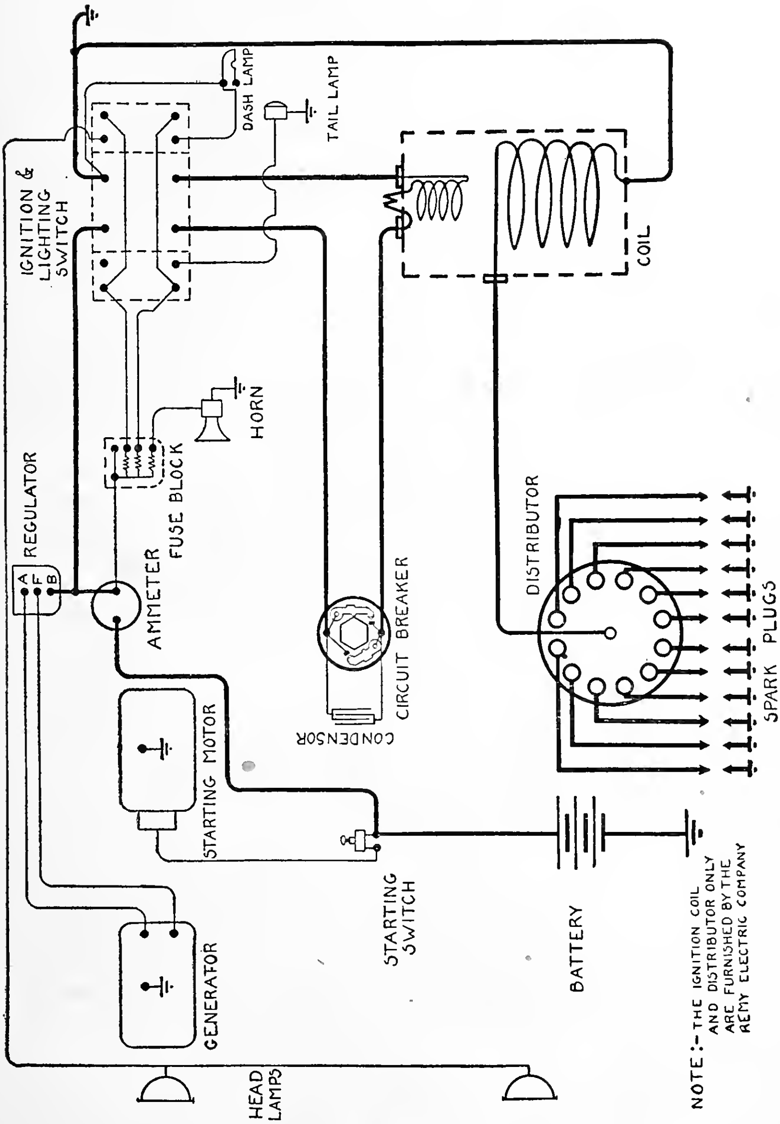
General Motors Truck Co.—Models 15, 25, 26, 30, 31, 40, 41, 70, 71, 100, 101
1917 Delco System



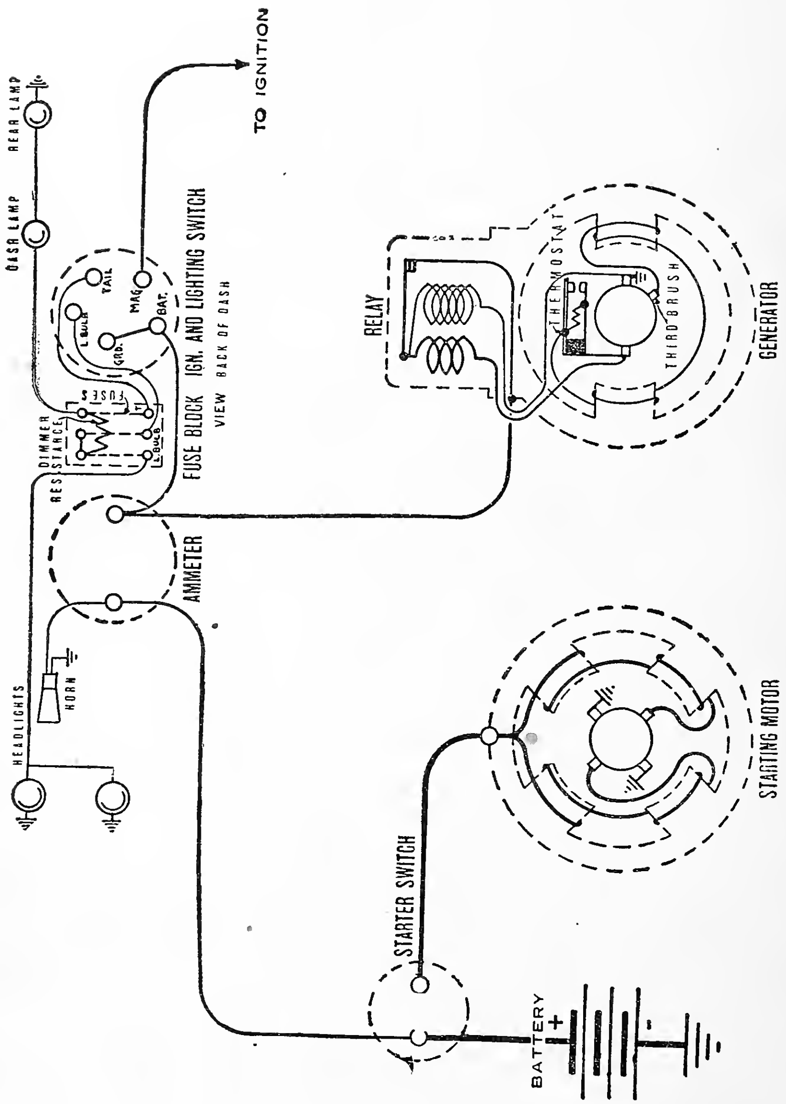
Grant—Model K, 1916 and 1917—Remy System



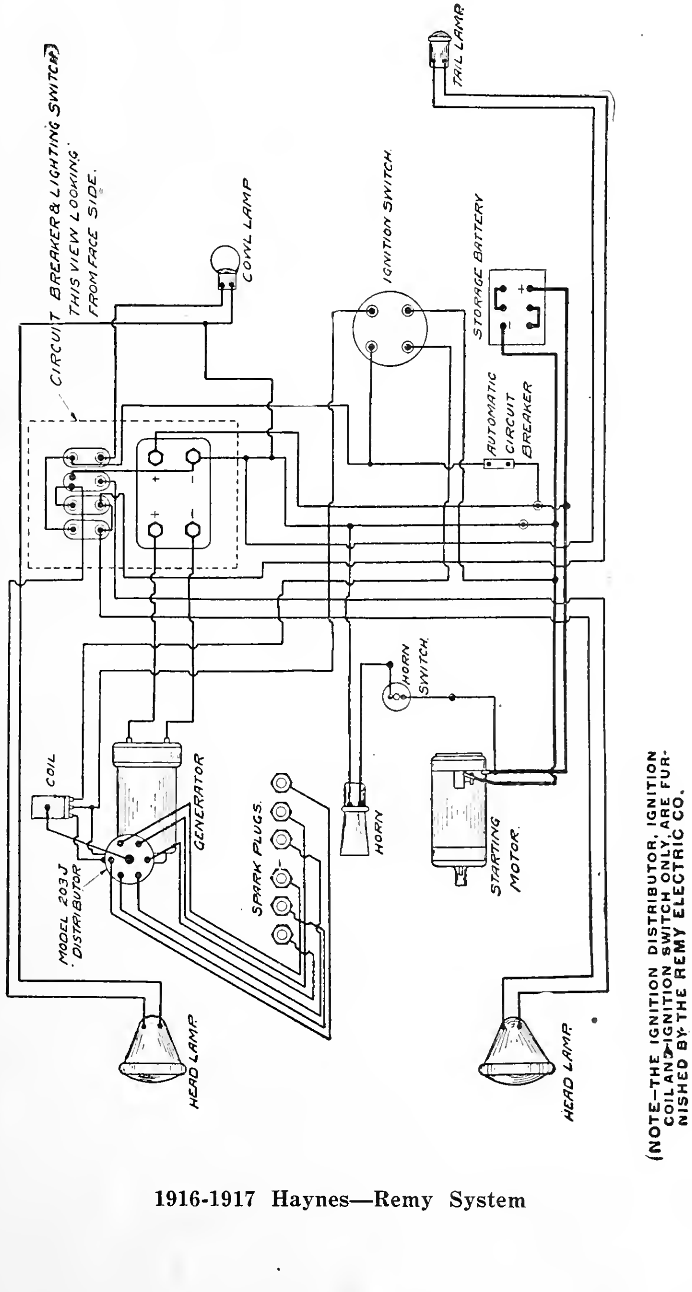
1917 Harley-Davidson—Remy System



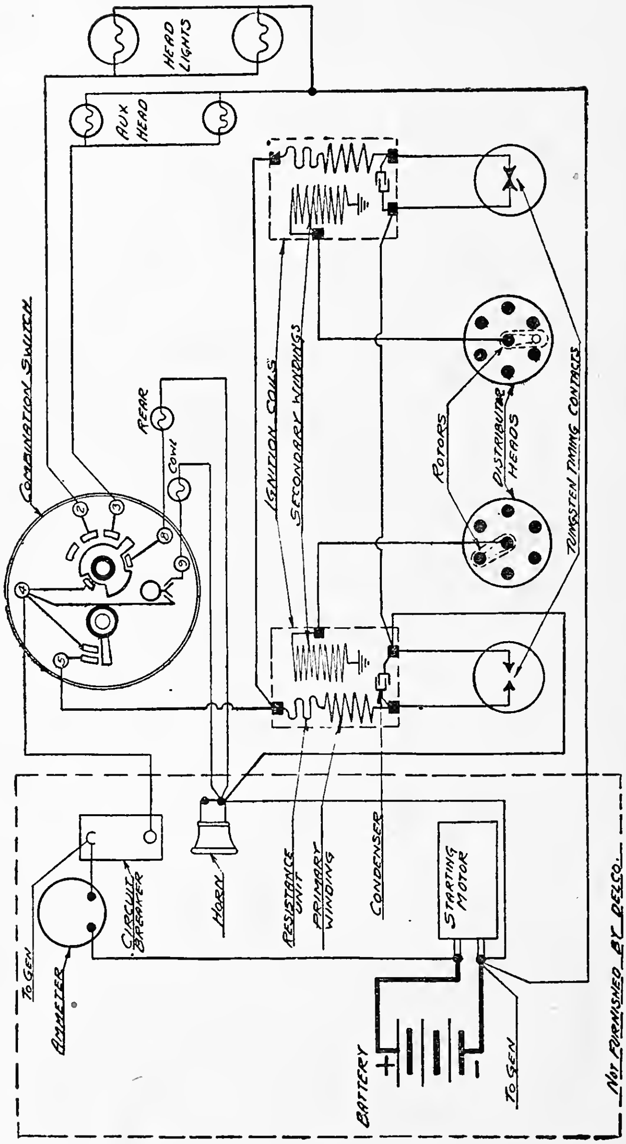
1917 H. A. L.—Remy System



Harroun A A 1—Remy System

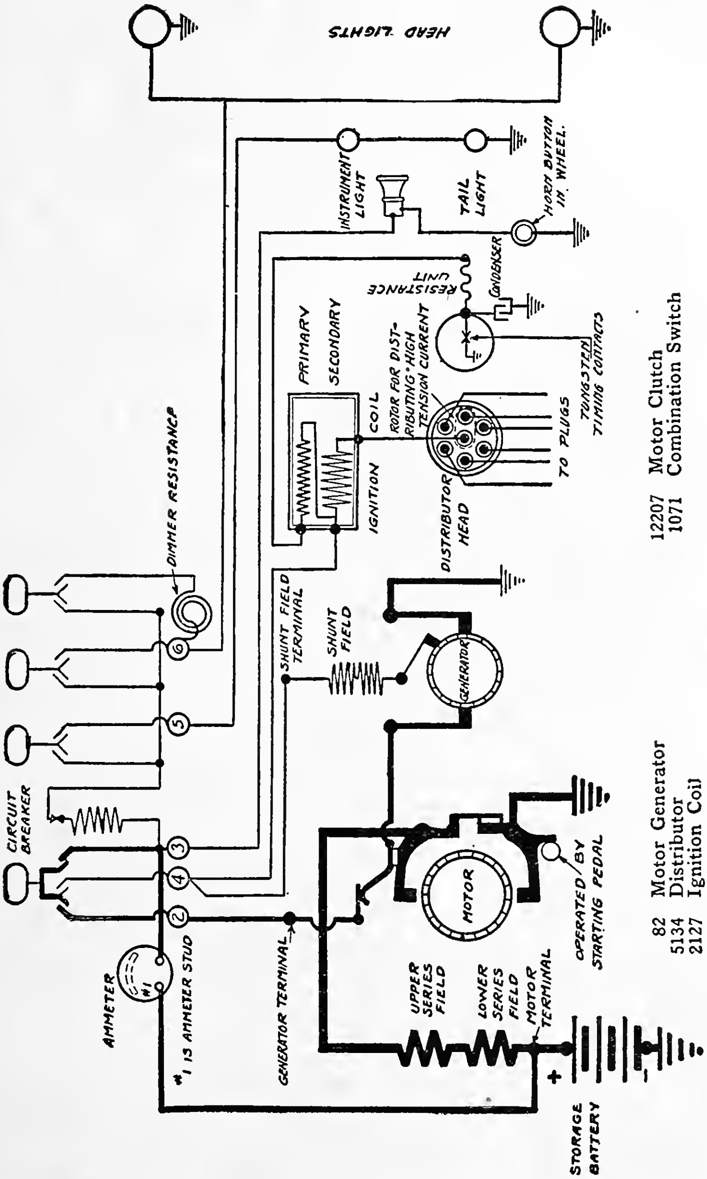


1916-1917 Haynes—Remy System

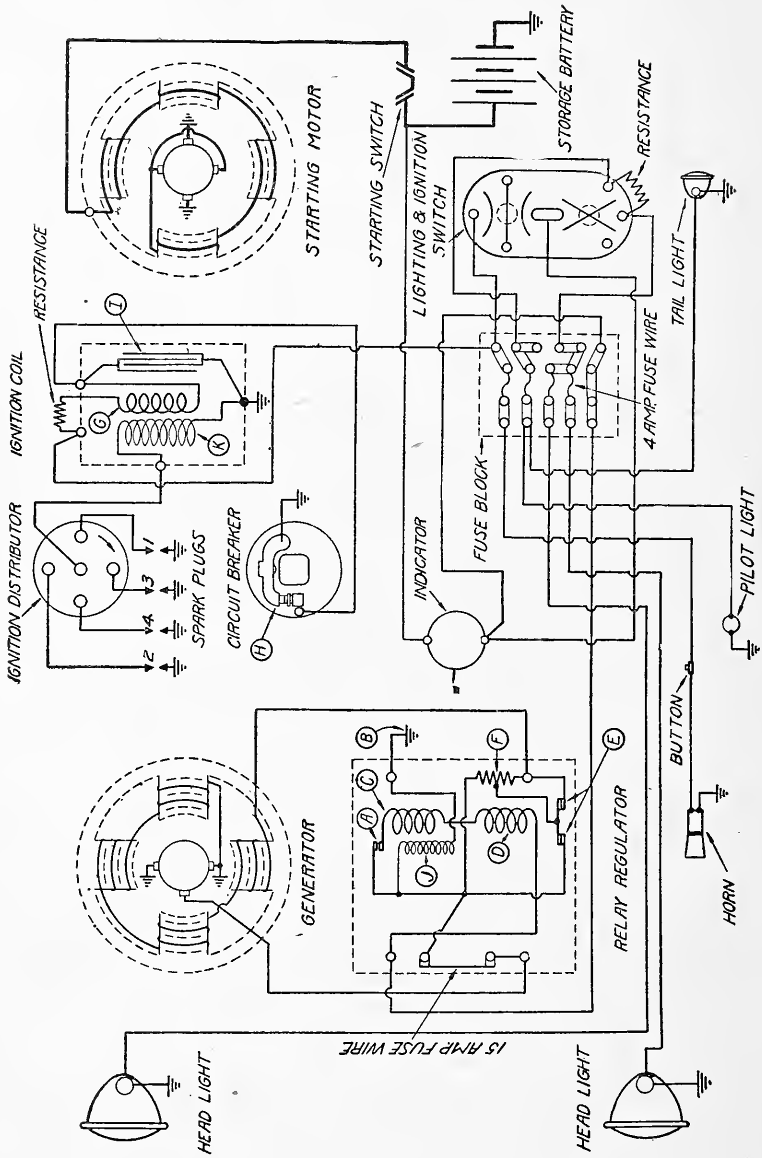


5155 Distributor (includes 2—2144 coils) 1083 Combination Switch

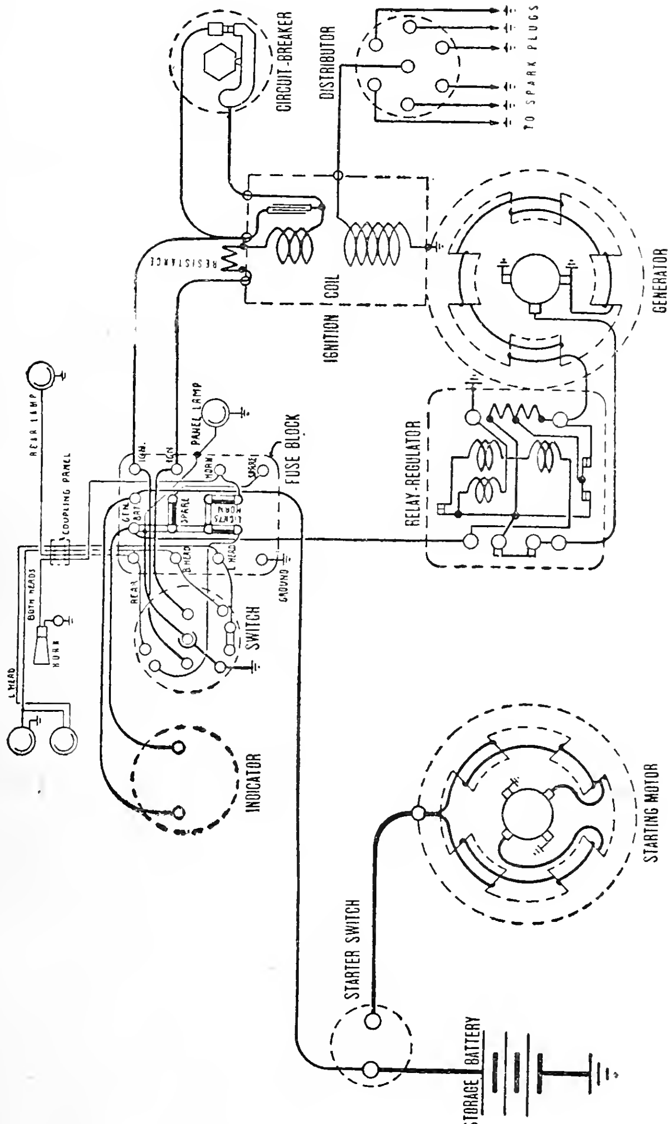
The Haynes Automobile Co.—Models 40-40-R-41—1917 Delco Ignition



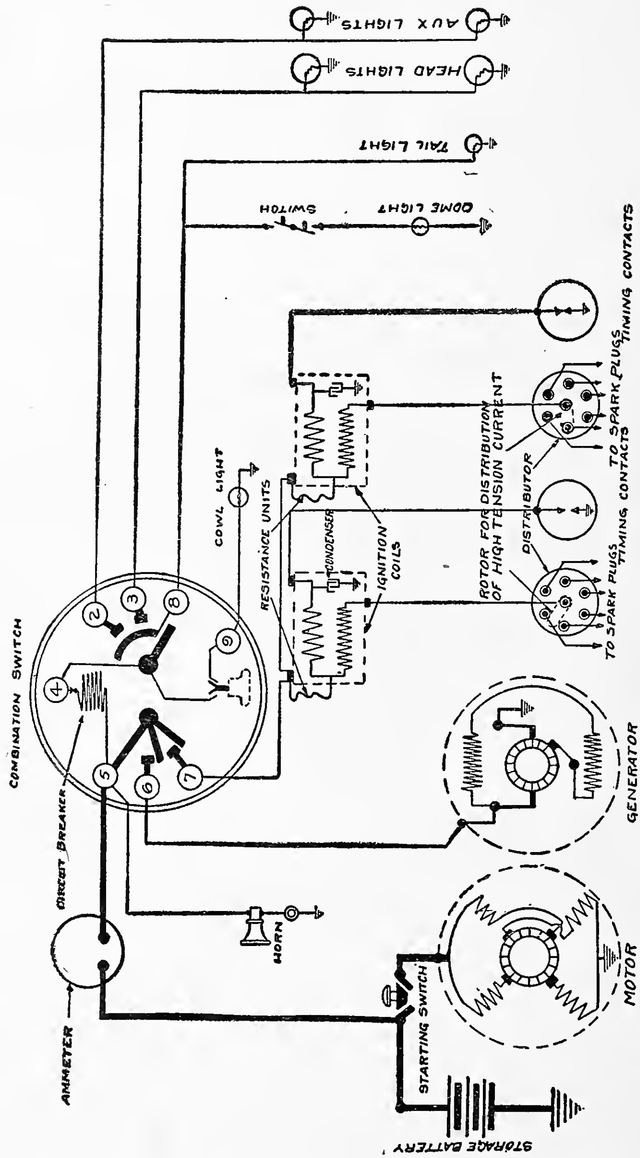
Hudson Motor Car Company—Super-Six Model—1917 Delco System



1916 and 1917 Interstate—Remy System

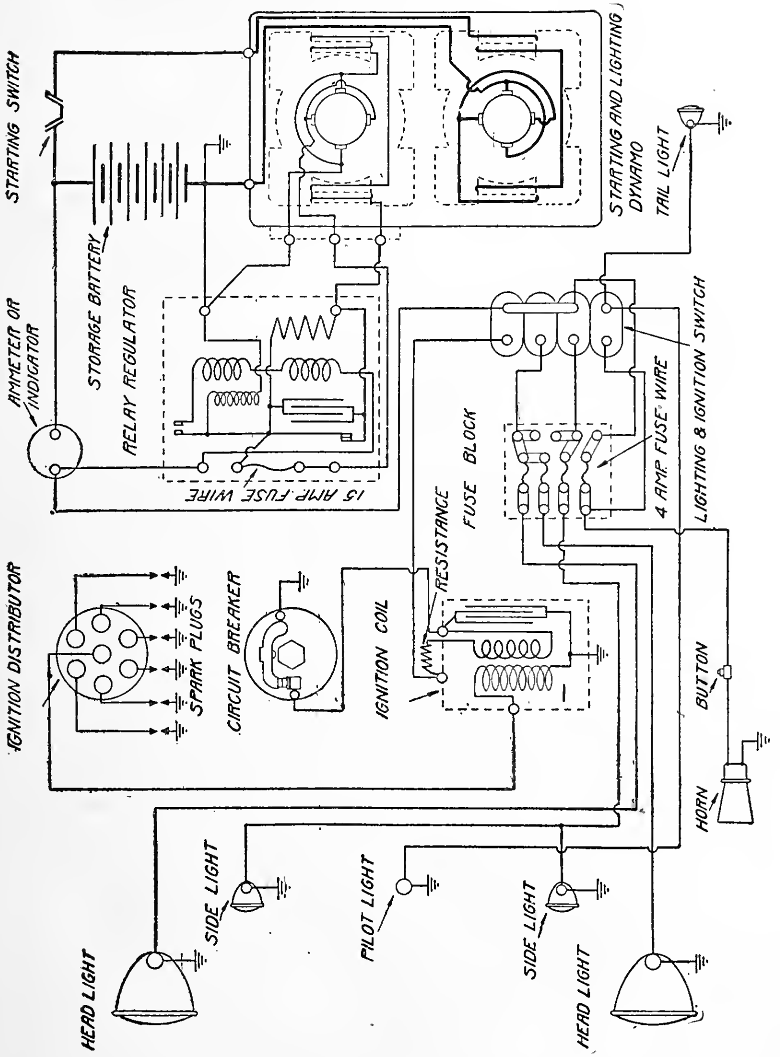


1916 Kissel 6—Remy System

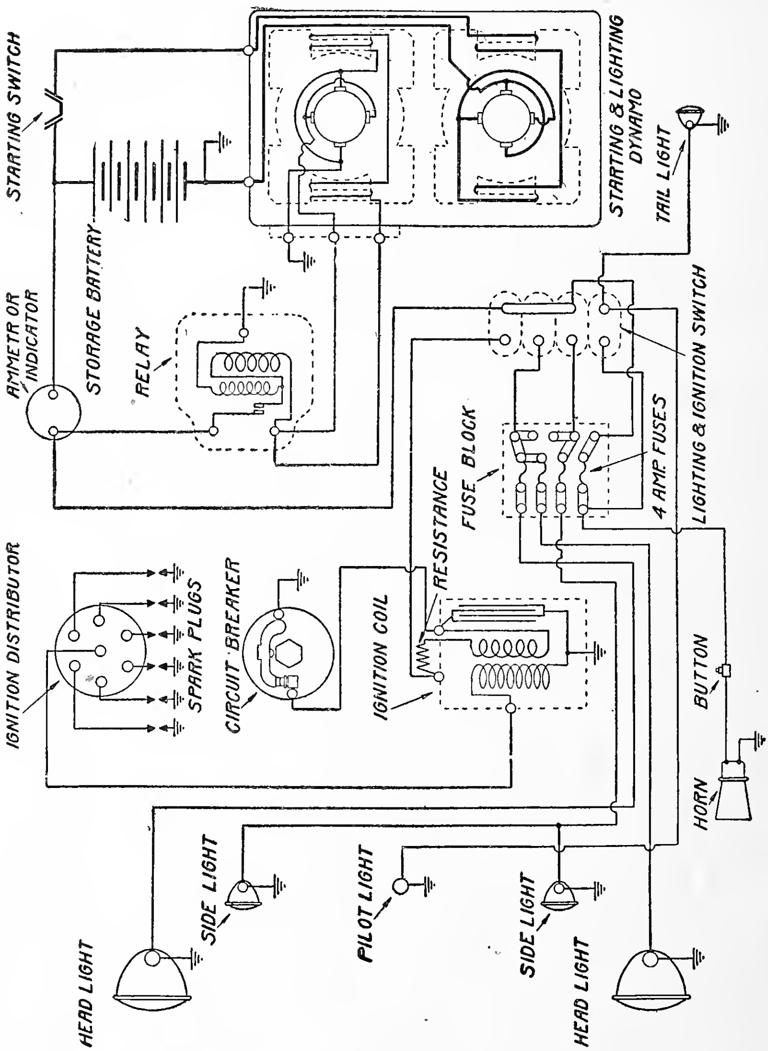


87	Generator	2123	Ignition Coil (2)	1966	Motor Switch
5156	Distributor	1093	Combination Switch	6063	Ammeter
		86	Motor		

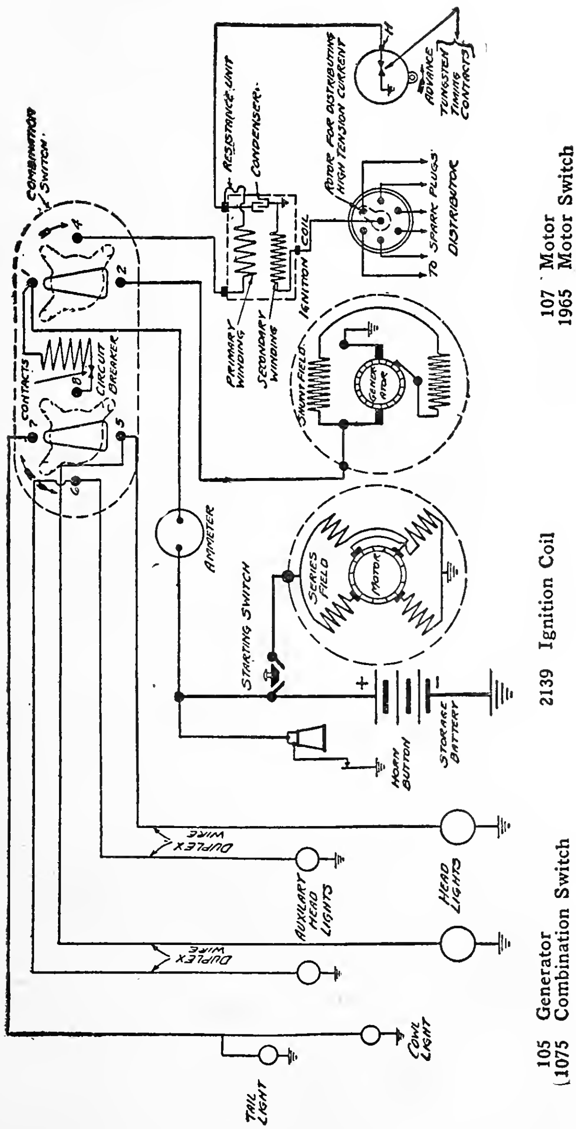
The Kissel Motor Company—12 Cylinder Model—1917 Delco System



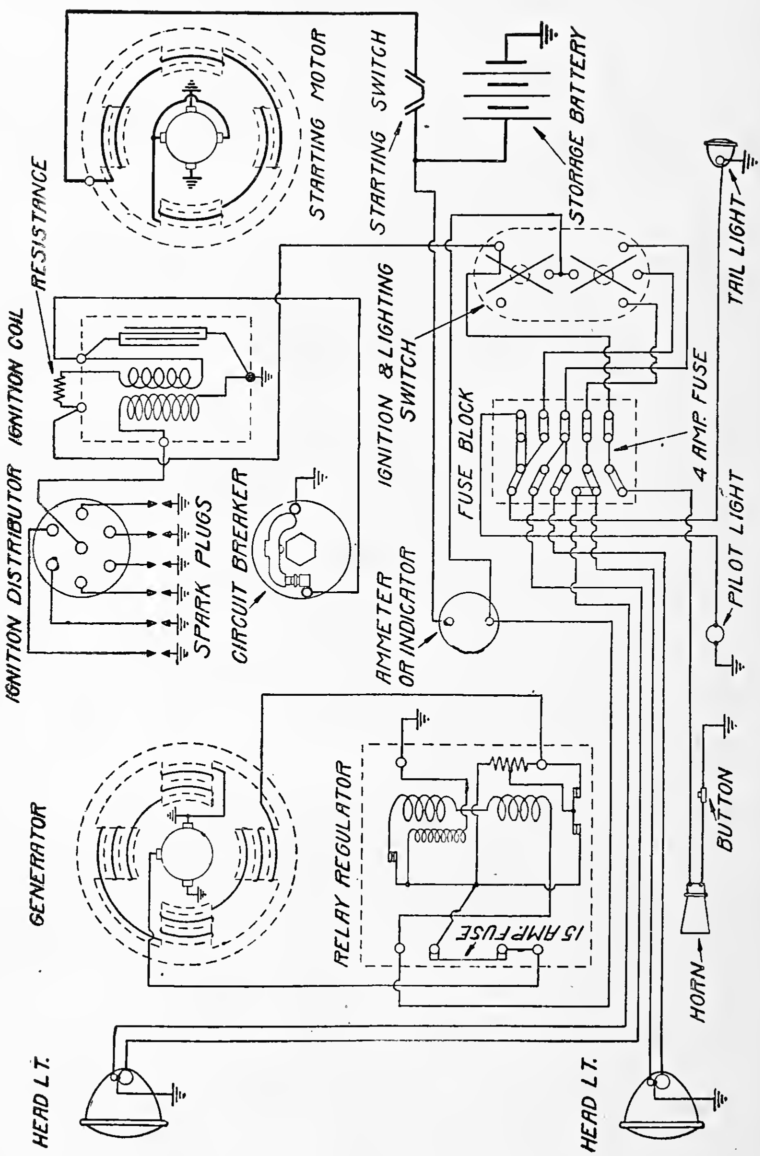
1915 L. P. C.—Remy System



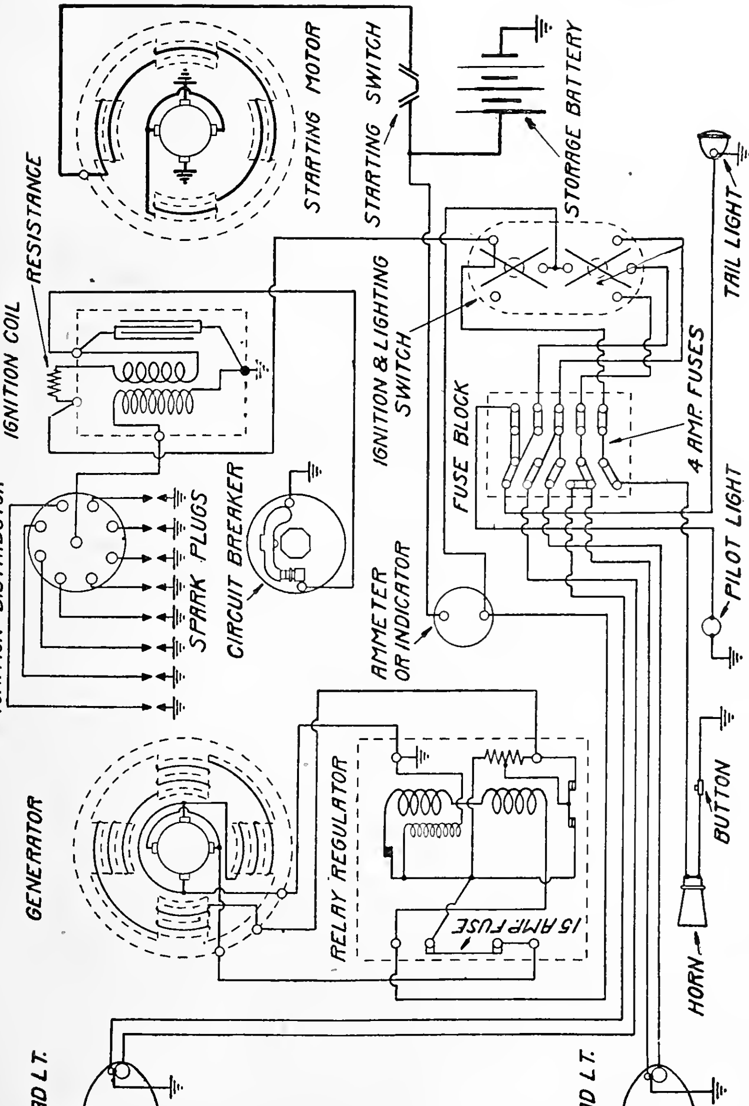
1916 L. P. C.—Remy System



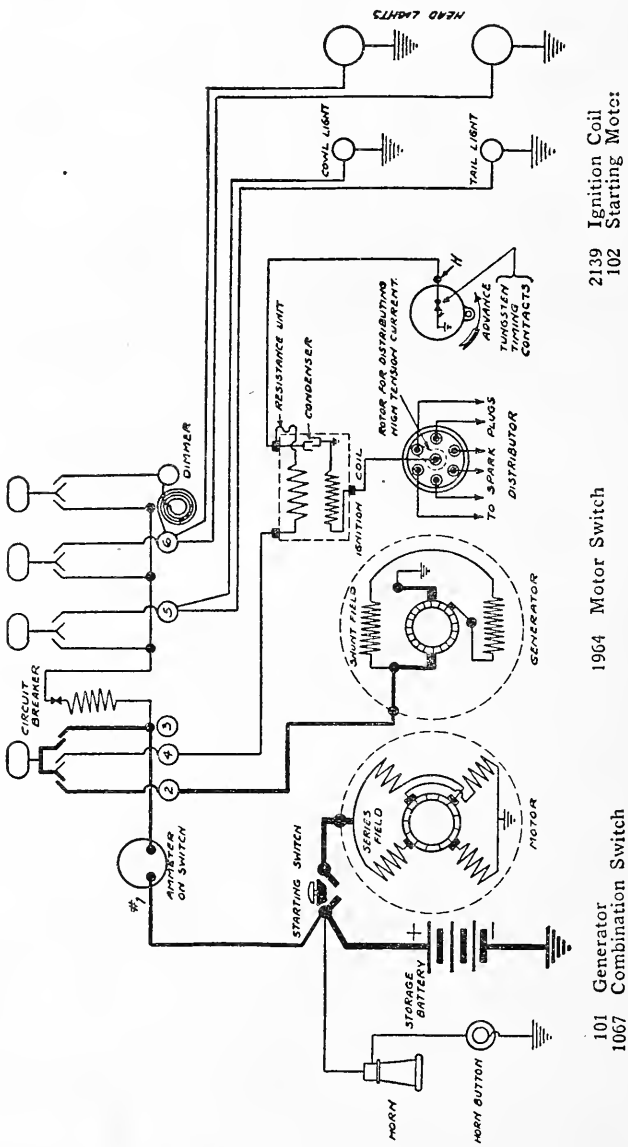
Liberty Motor Car Company—1917 Delco System



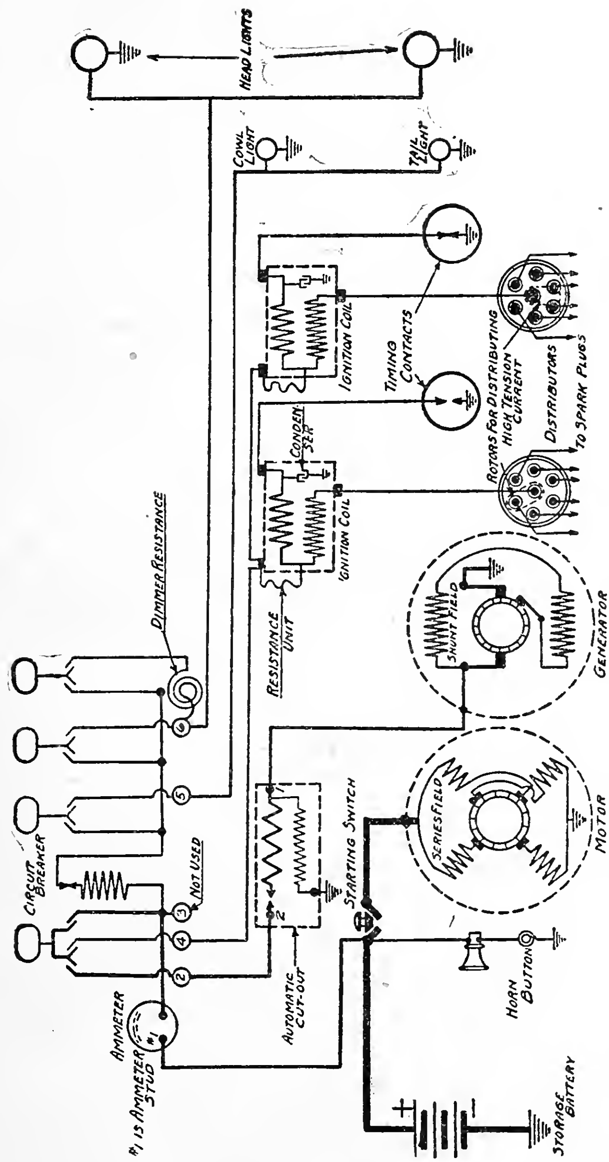
Madison 6-Cylinder—Remy System



Madison 8-Cylinder—Remy System

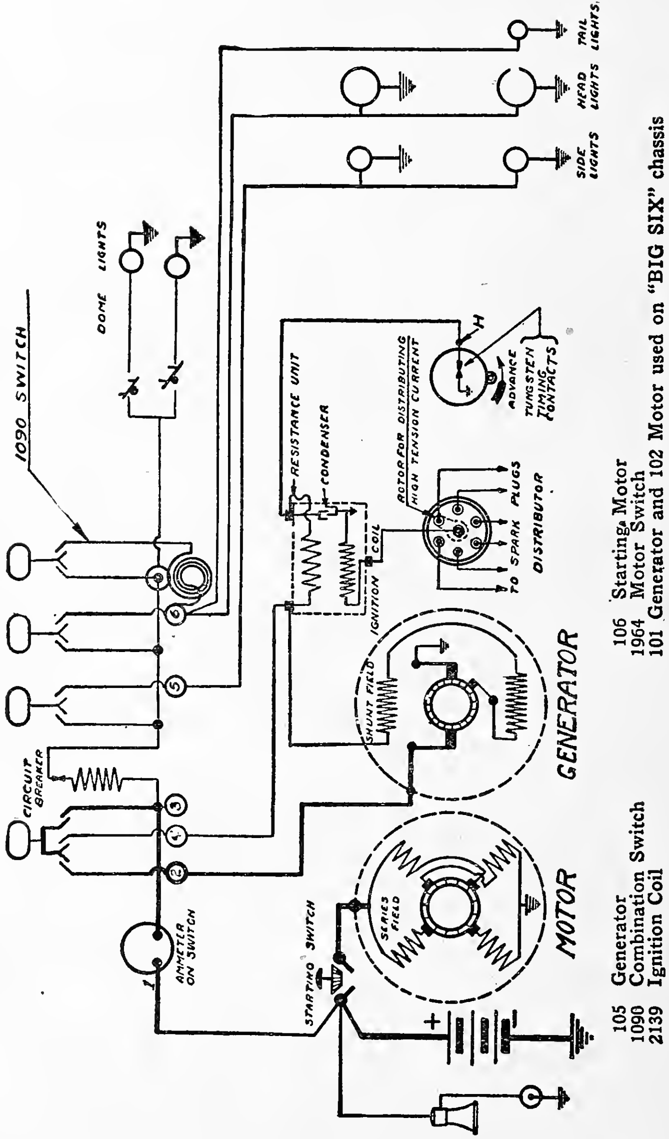


Meteor Motor Car Company—Models 75 and 80—1917 Delco System

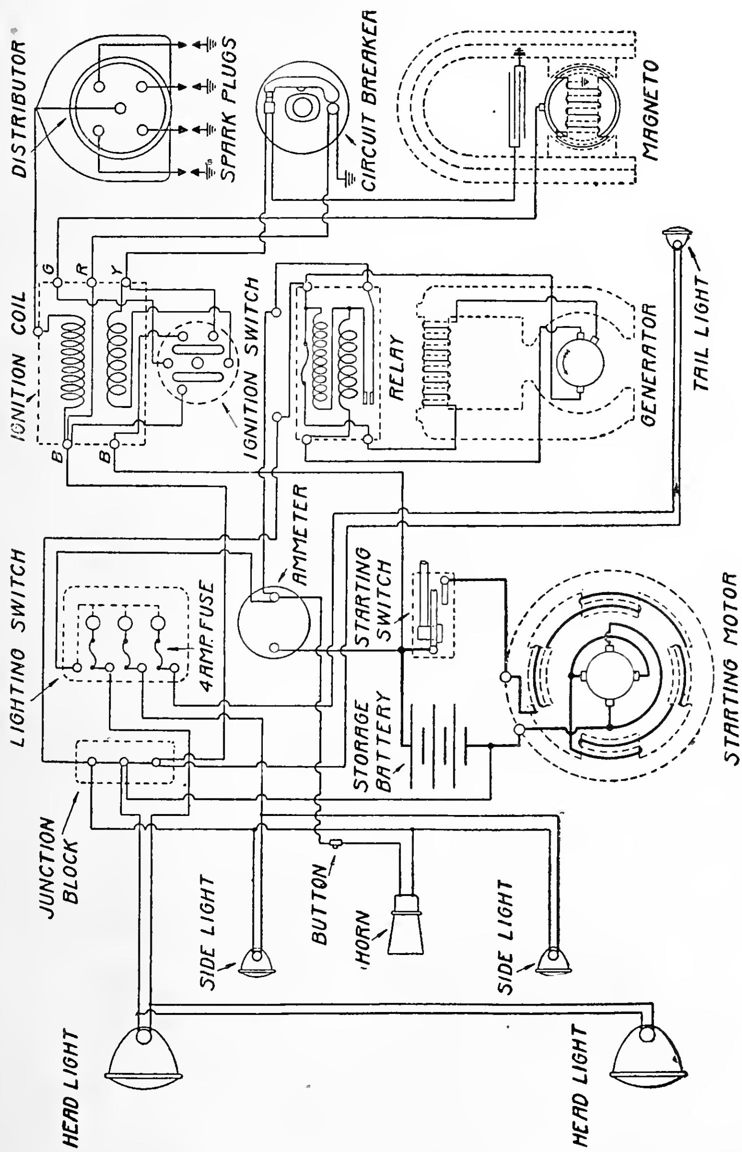


87	Generator	5136	Distributor
5715	Automatic Cut-Out	2123	Ignition Coil (2)
86	Motor	1067	Combination
		1965	Motor Switch

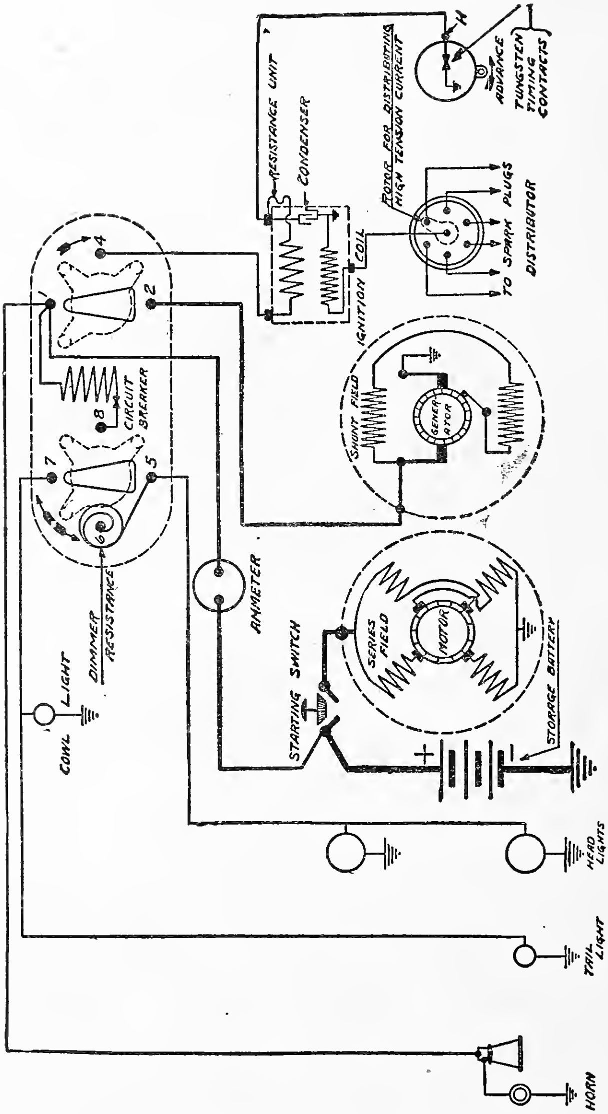
Meteor Motor Car Company—Models 75-A-80-A—1917 Delco System



Michigan Hearse & Motor Company—"Light Six" and "Big Six" Chassis
1917 Delco System

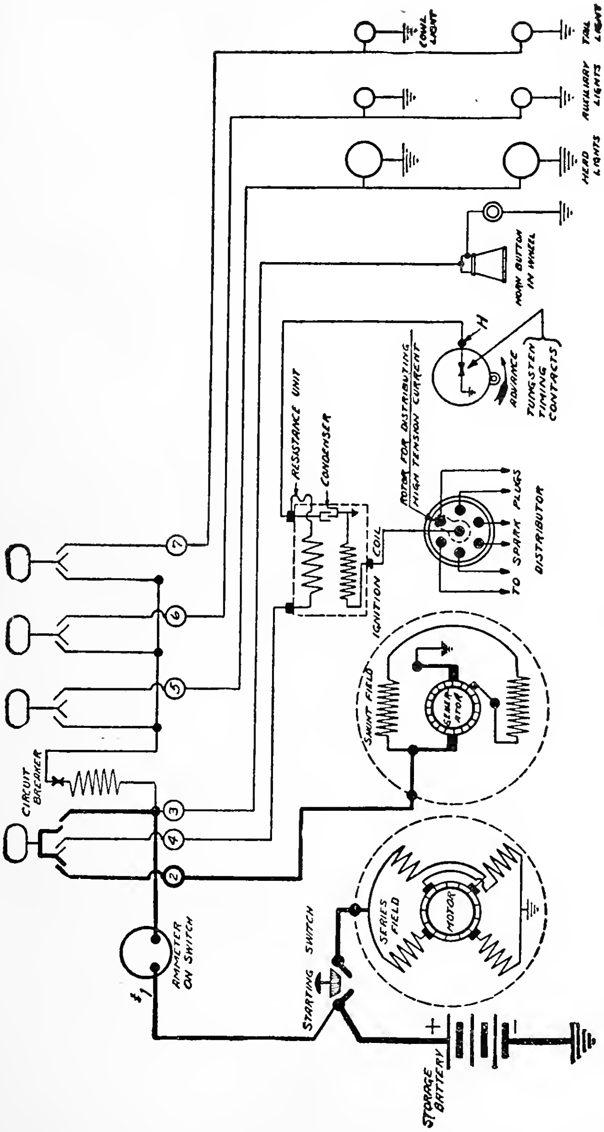


1914 and 1915 Mitchell Lewis—Remy System



105 Generator
1078 Combination Switch
2139 Igintion Coil
'106 Motor
1964 Motor Switch
6059 Ammeter

Moon Motor Car Company—Model 6-43—1917 Delco System

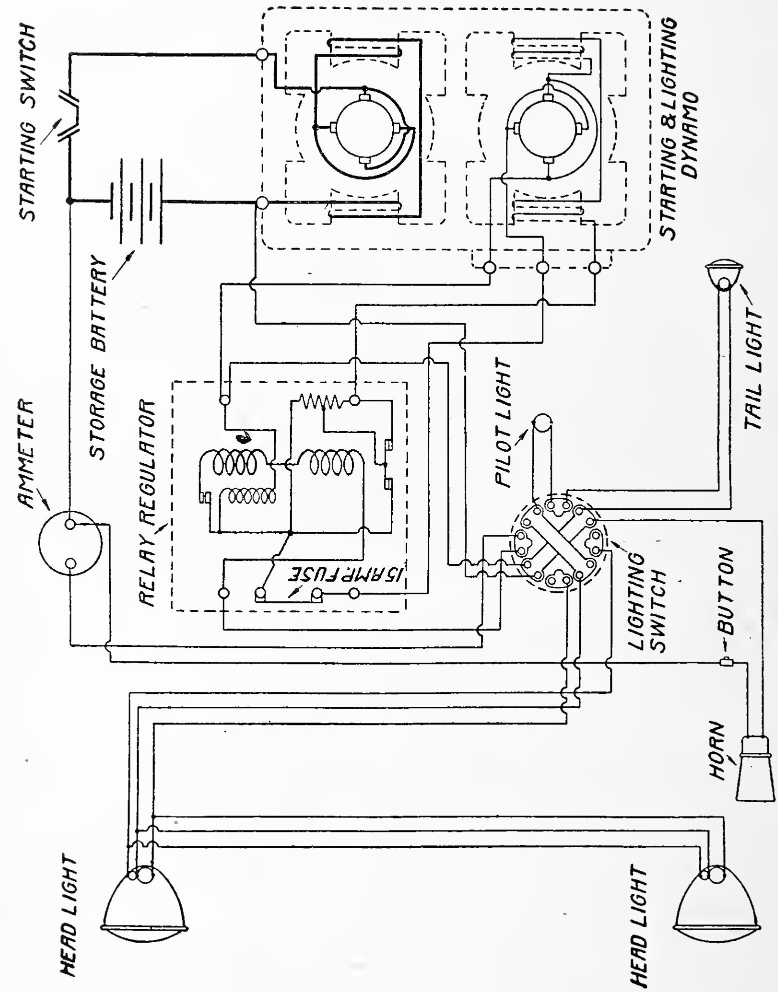


101 Generator
1081 Combination Switch

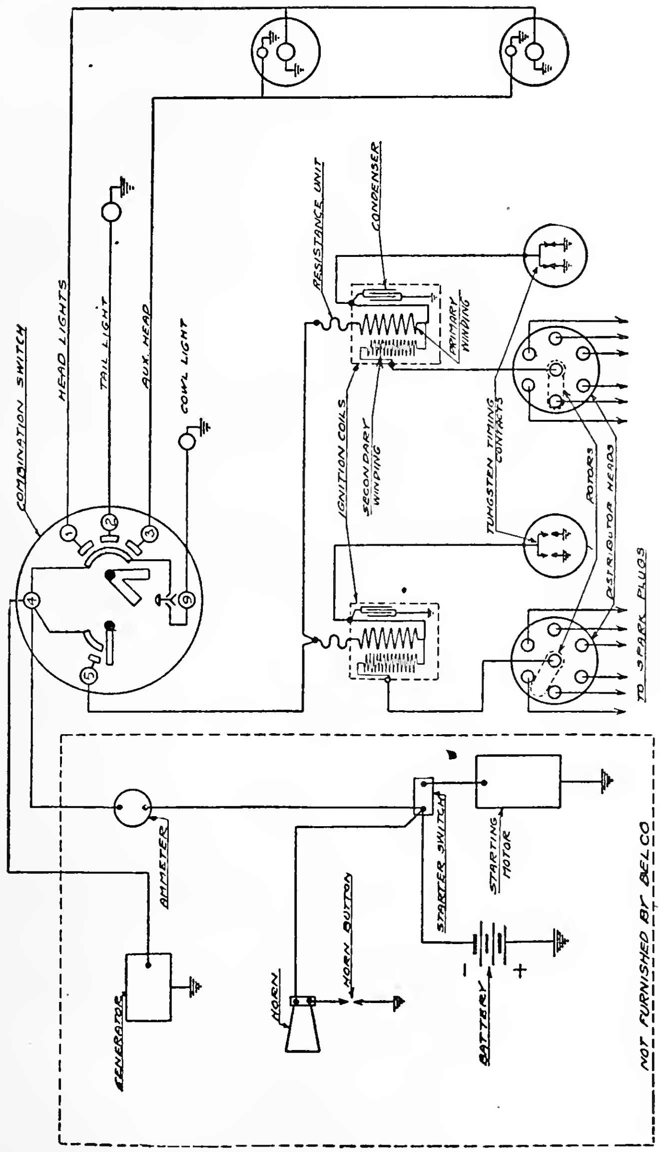
2139 Ignition Coil

102 Motor
1964 Motor Switch

Moon Motor Car Company—Model 6-66—1917 Delco System

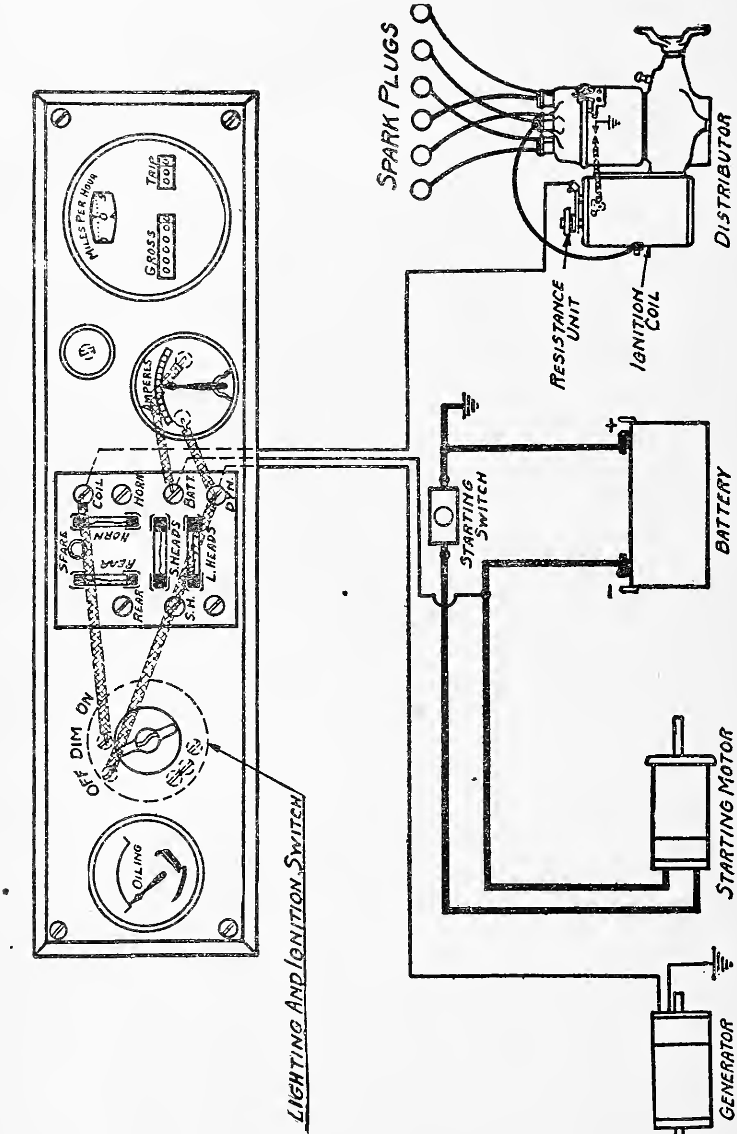


1914 National—Remy System



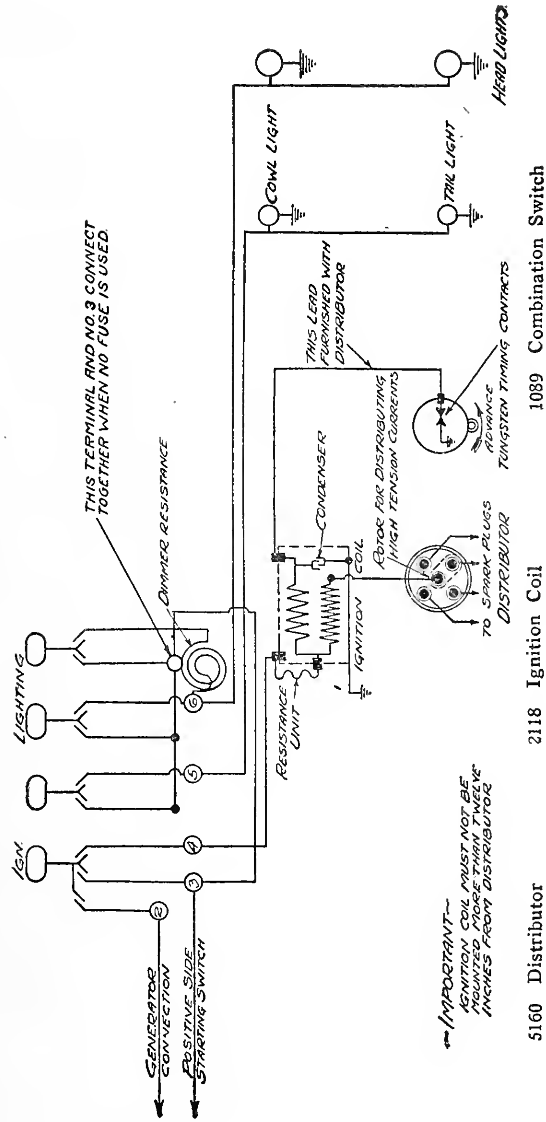
5162 Distributor including two ignition coils No. 2152.

National Motor Car & Vehicle Corp.—Series A-K—1917 Delco System

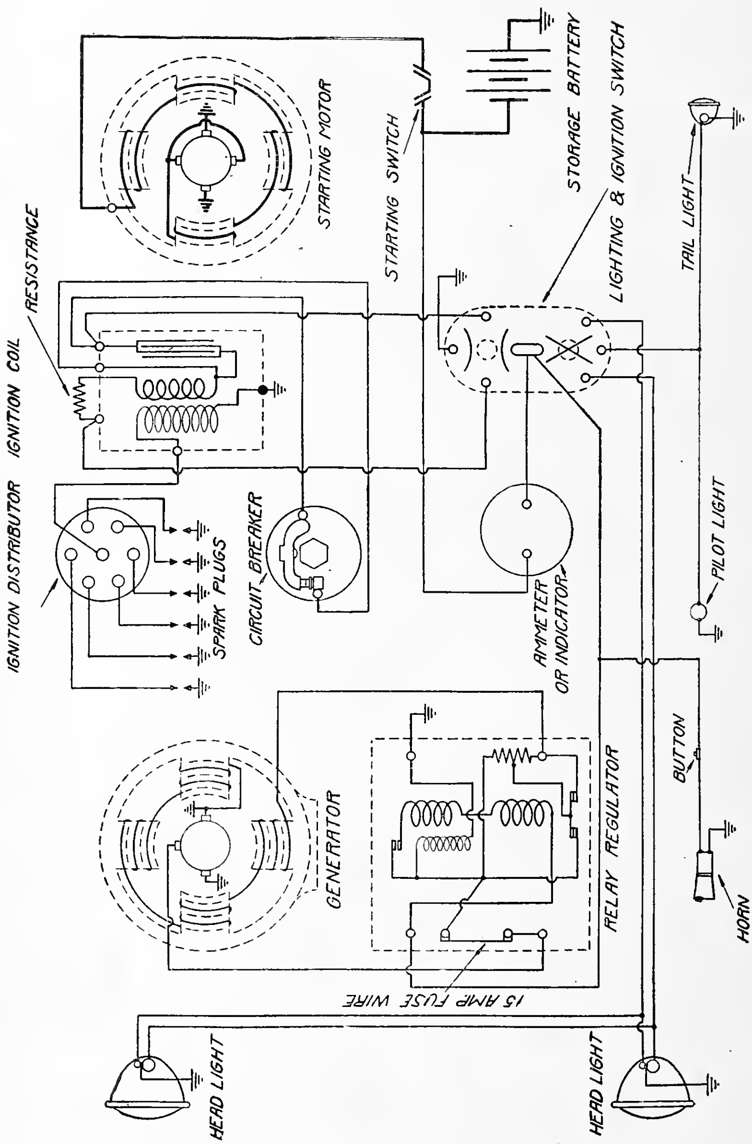


5163 Distributor including one 2155 Coil

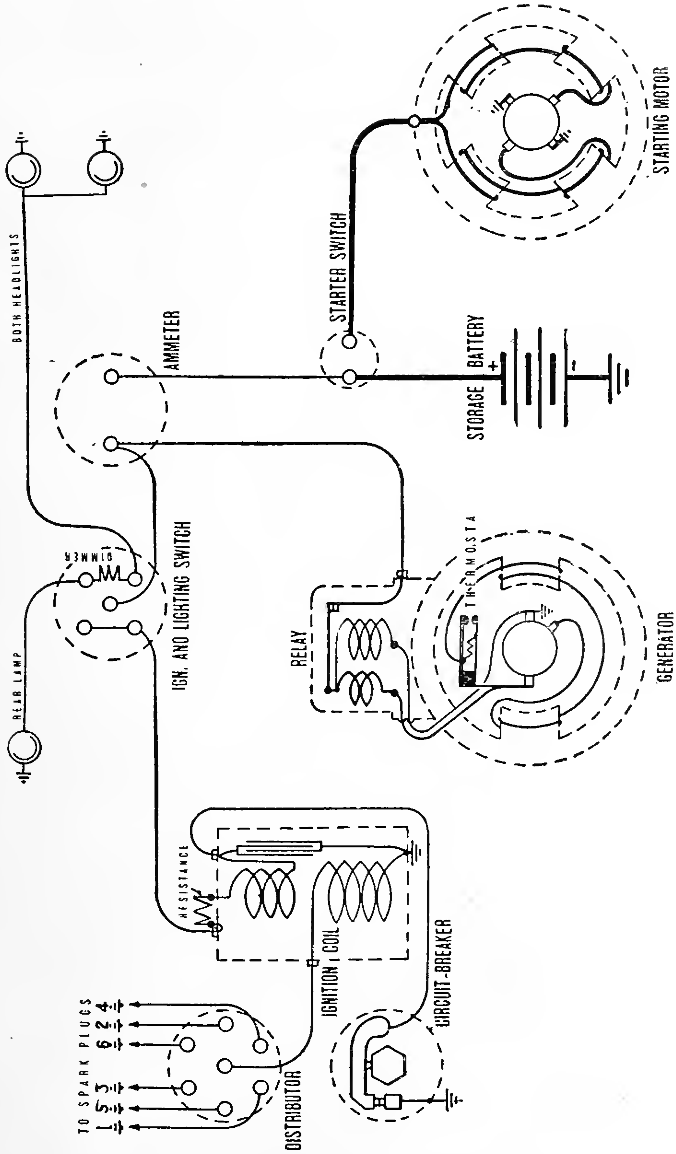
The Nash Motors Company—1917 Delco System



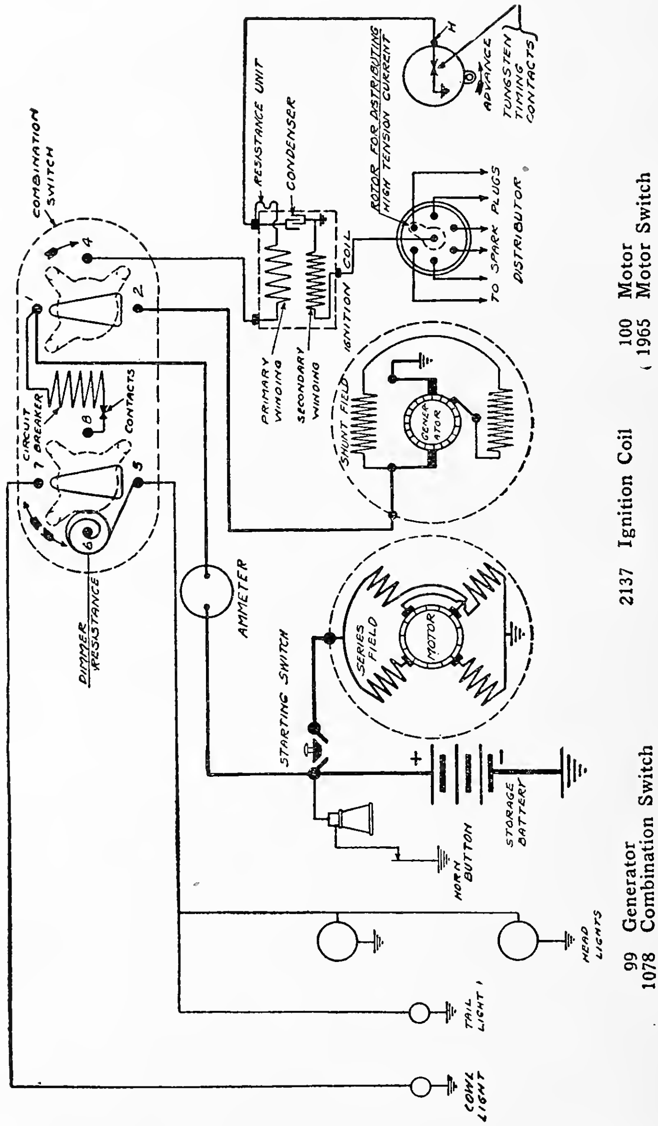
Norwalk Motor Car Company—1917 Delco System



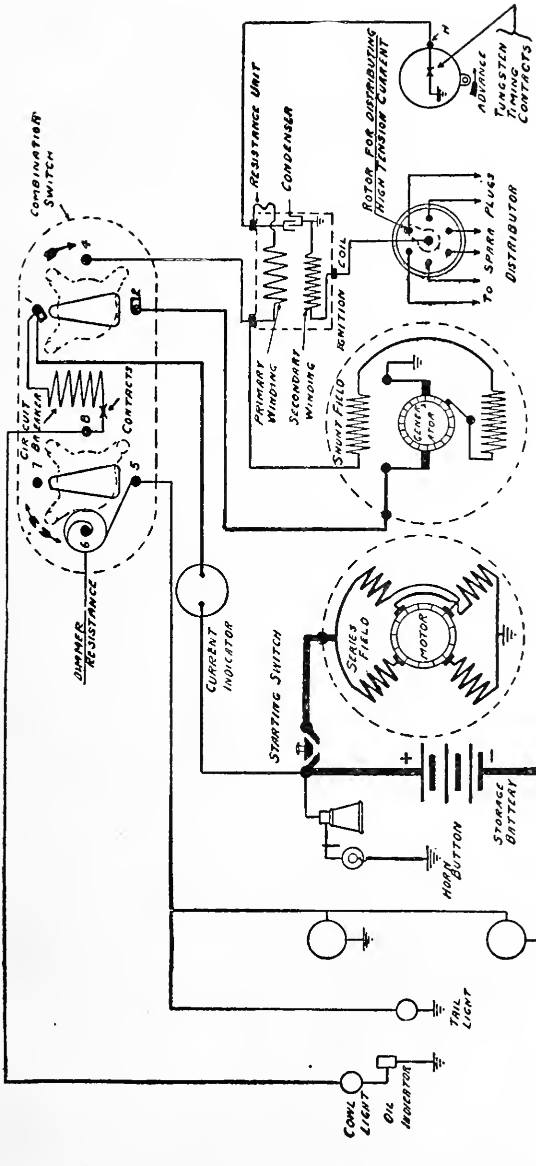
Oakland—Model 32—Remy System



Oakland—Model 34-B—Remy System

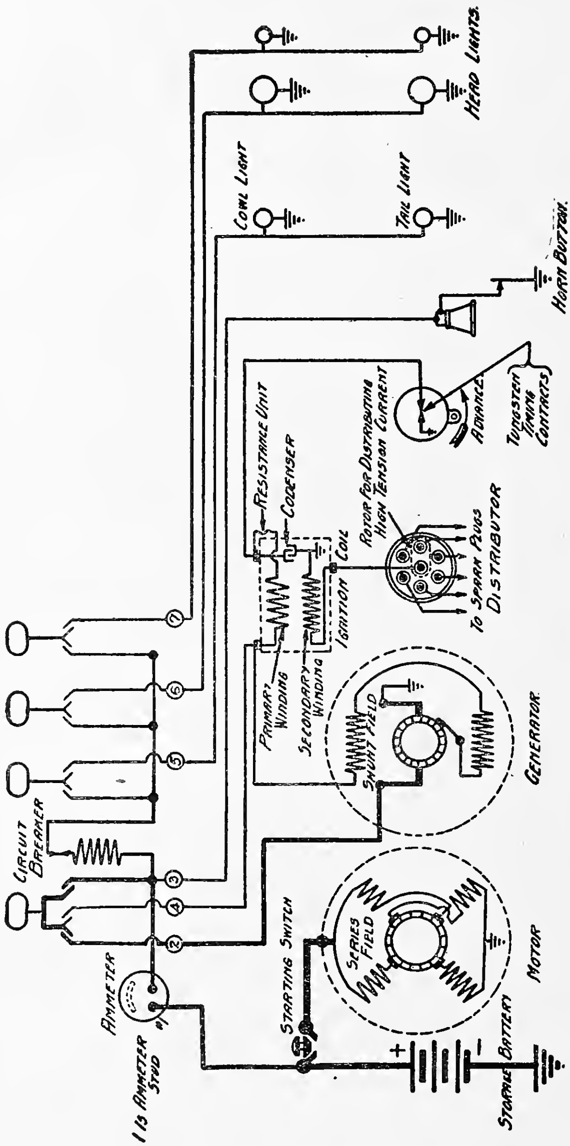


Oakland Motor Car Company—Model 32-B—1917 Delco System



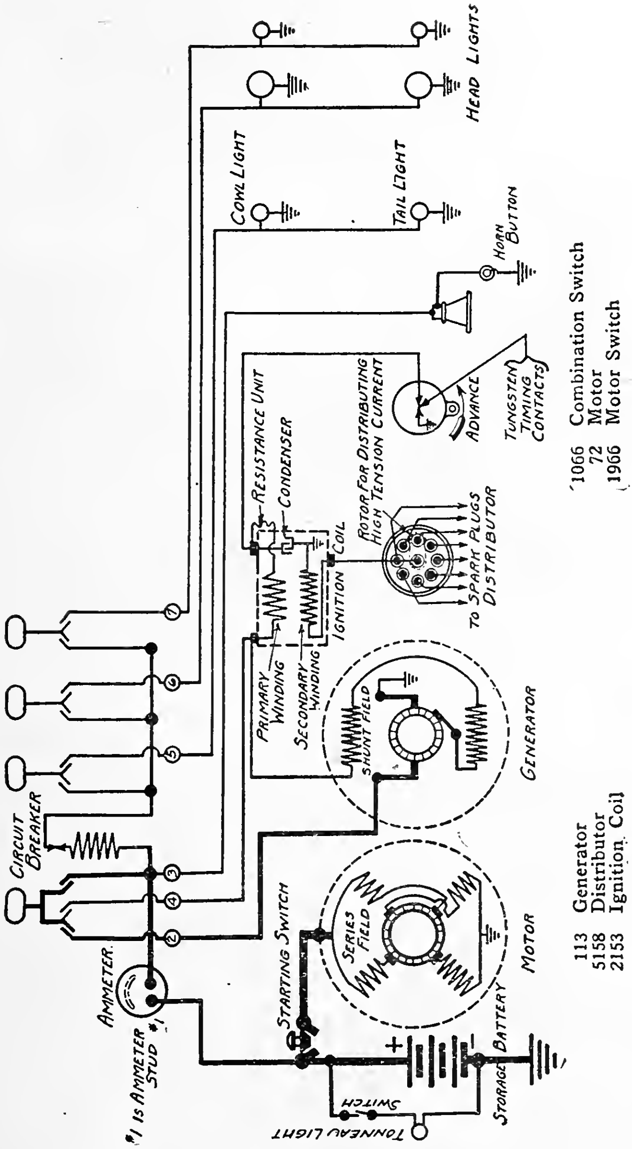
111 Generator
1078 Combination Switch
1965 Motor Switch
2137 Ignition Coil
100 Motor

Oakland Motor Car Company—Model 34—1917 Delco System

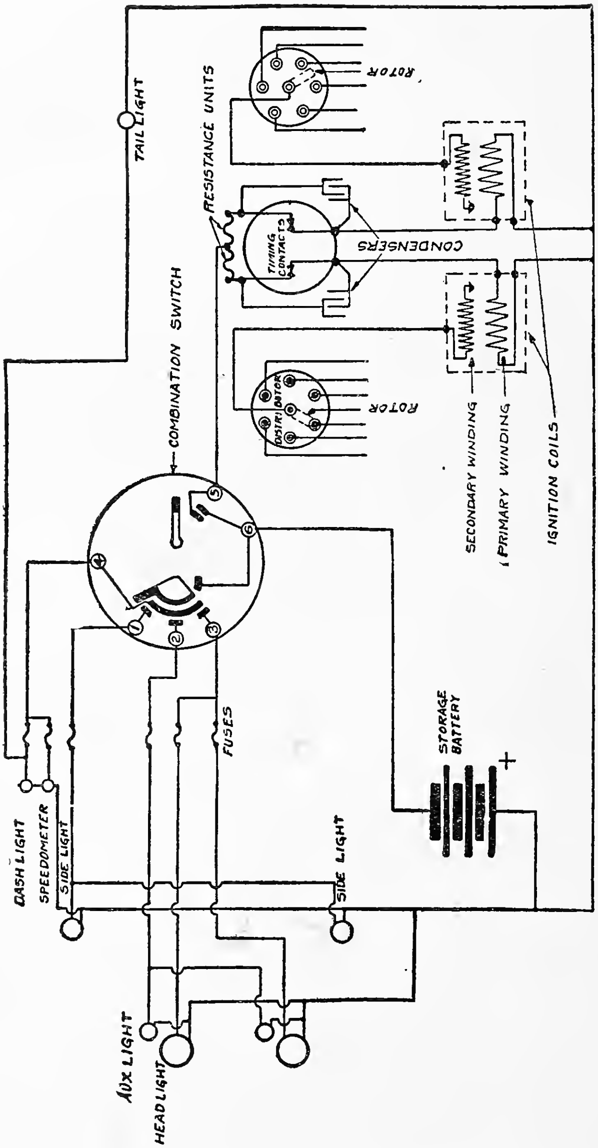


111 Generator
1066 Combination Switch
2137 Ignition Coil
100 Motor
1966 Motor Switch

Olds Motor Works—Model 37, 1917—1917 Delco System

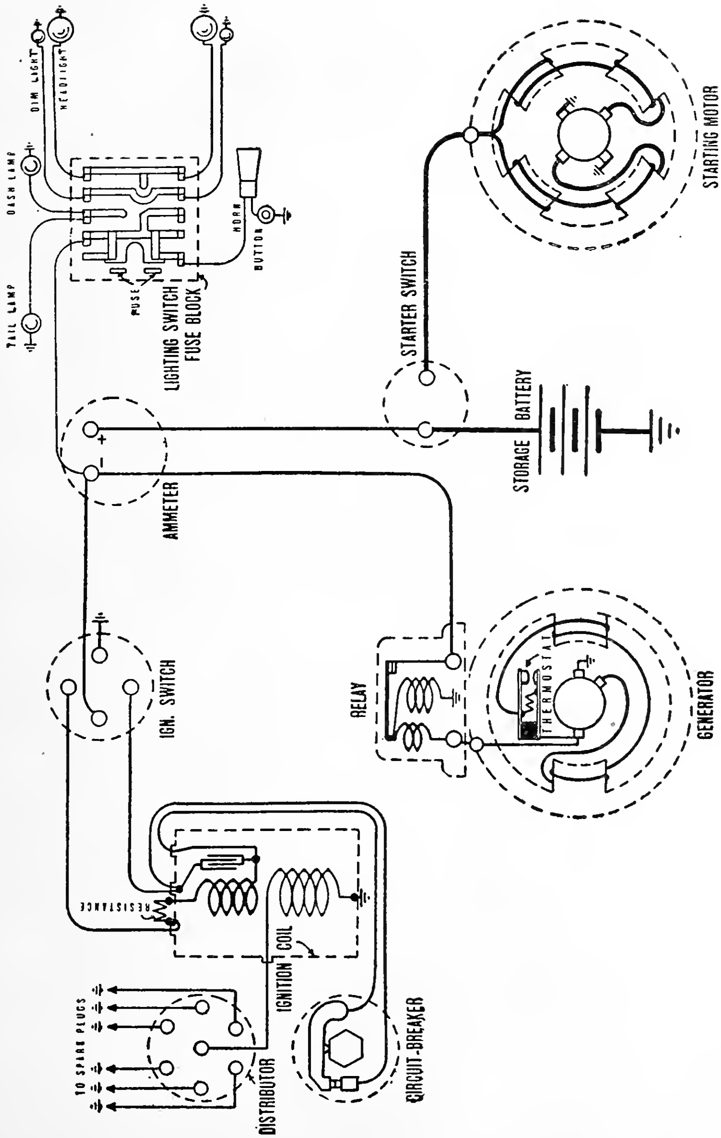


Olds Motor Works—Model 45—1917 Delco System

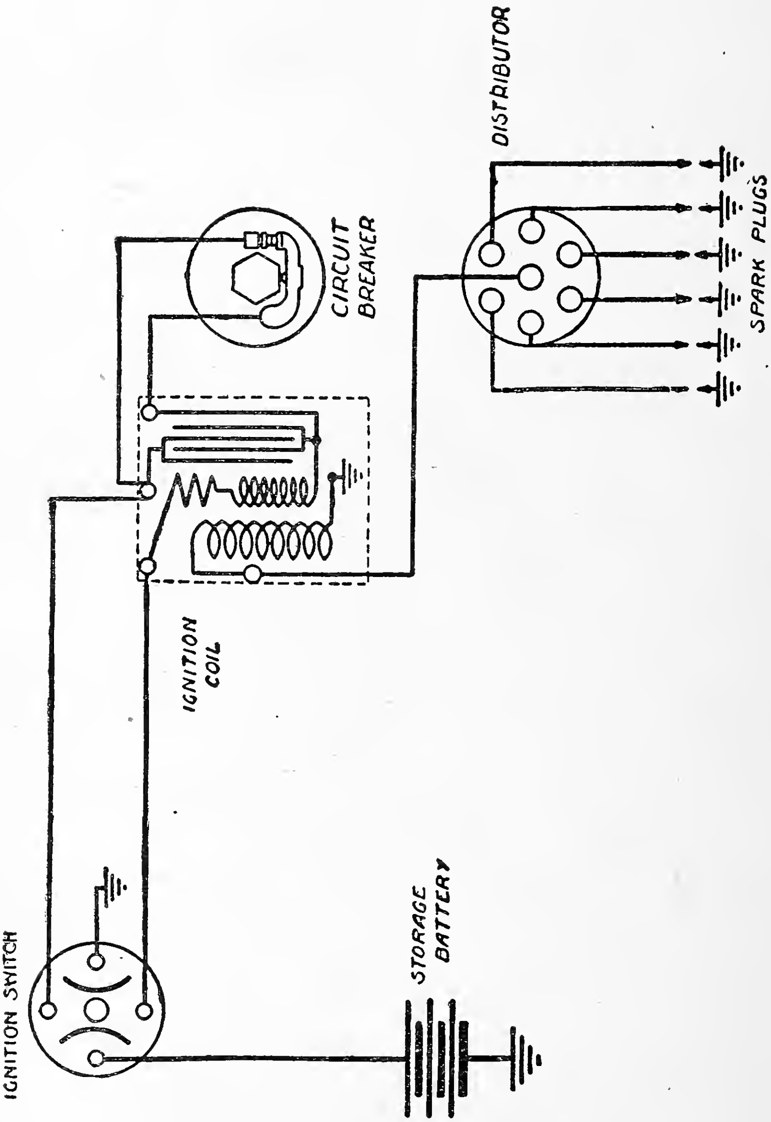


5149 Distributor 2135 Ignition Coil (2) 1076 Combination Switch

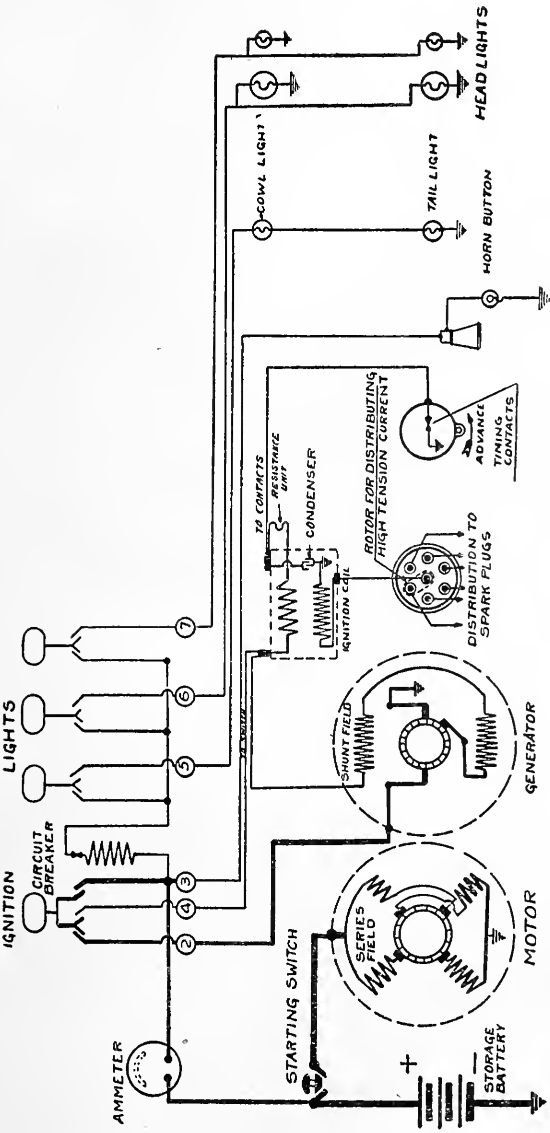
Packard Motor Car Company—Models 2-25 and 2-35—1917 Delco System



Paige 1917—Remy System

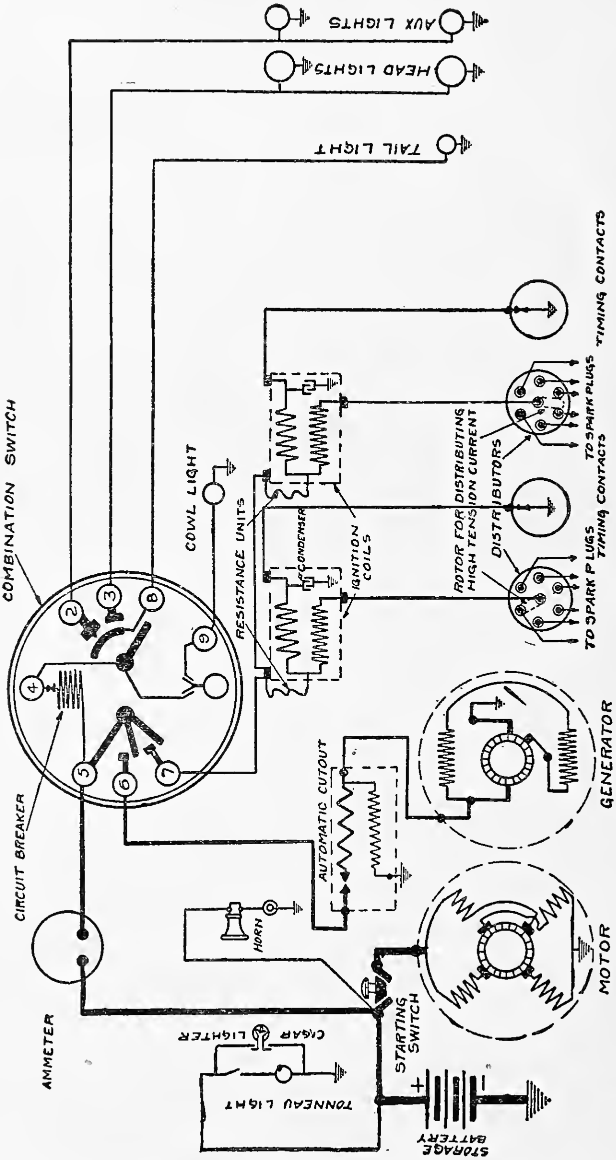


1916 and 1917 Paige 6—Remy Ignition



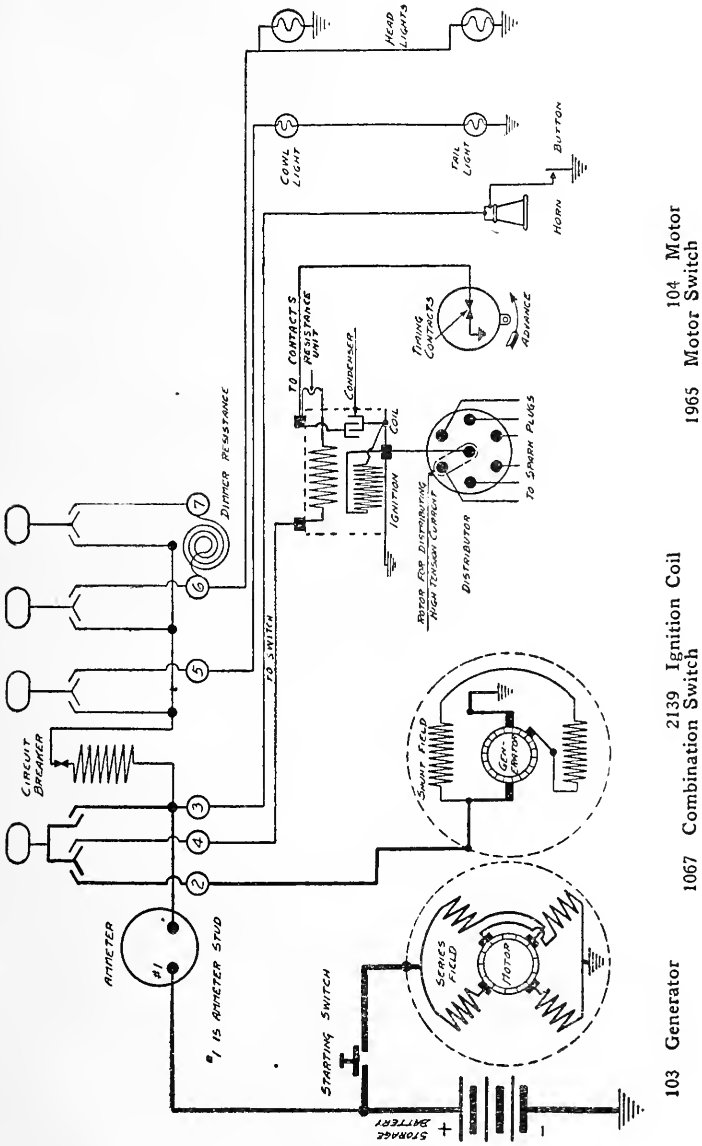
105 Generator
1066 Combination Switch
2139 Ignition Coil
106 Motor
1964 Motor Switch

W. A. Paterson Company—Models 6-45 and 6-45-R—1917 Delco System

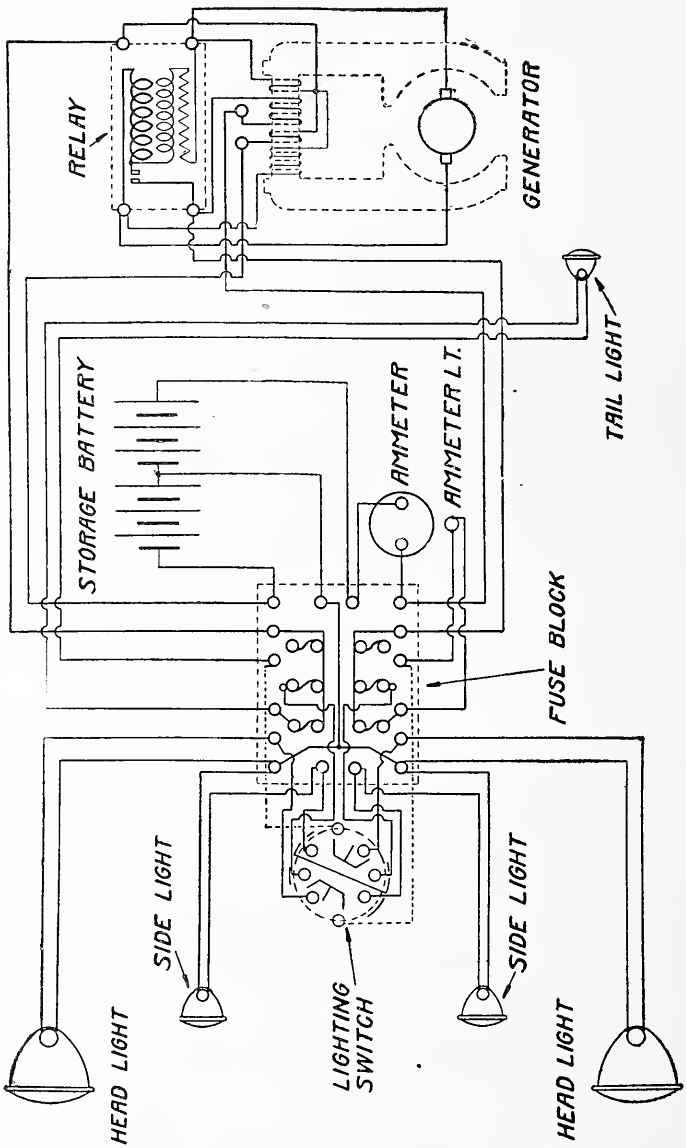


87 Generator	2123 Ignition Coil (2)	6064 Ammeter	86 Motor
5156 Distributor	1082 Combination Switch		1966 Motor Switch

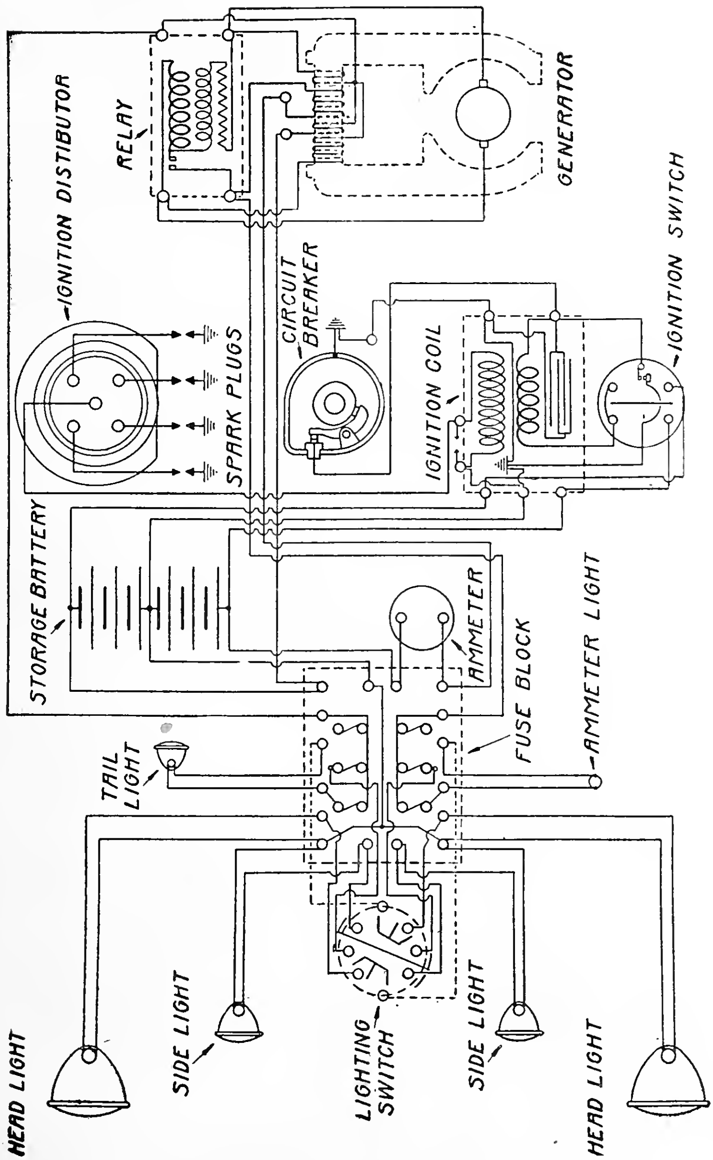
The Pathfinder Company—12 Cylinder Model—1917 Delco System



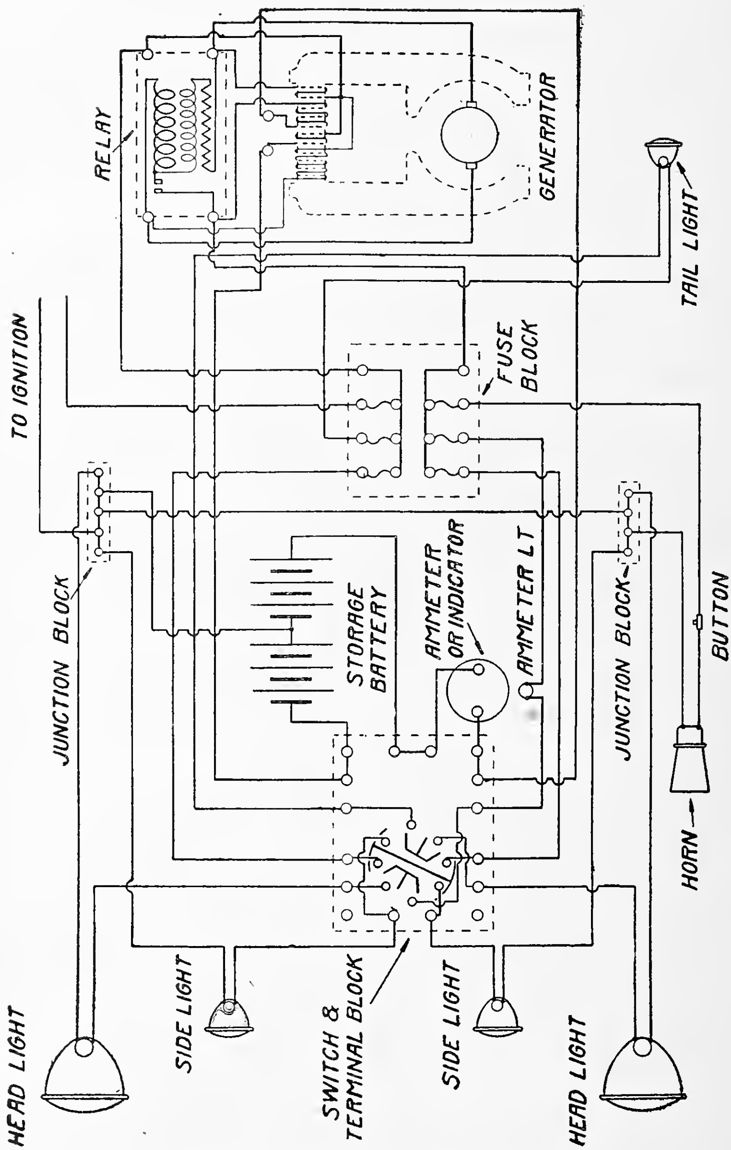
Pilot Motor Car Company—Model 6-45—1917 Delco System



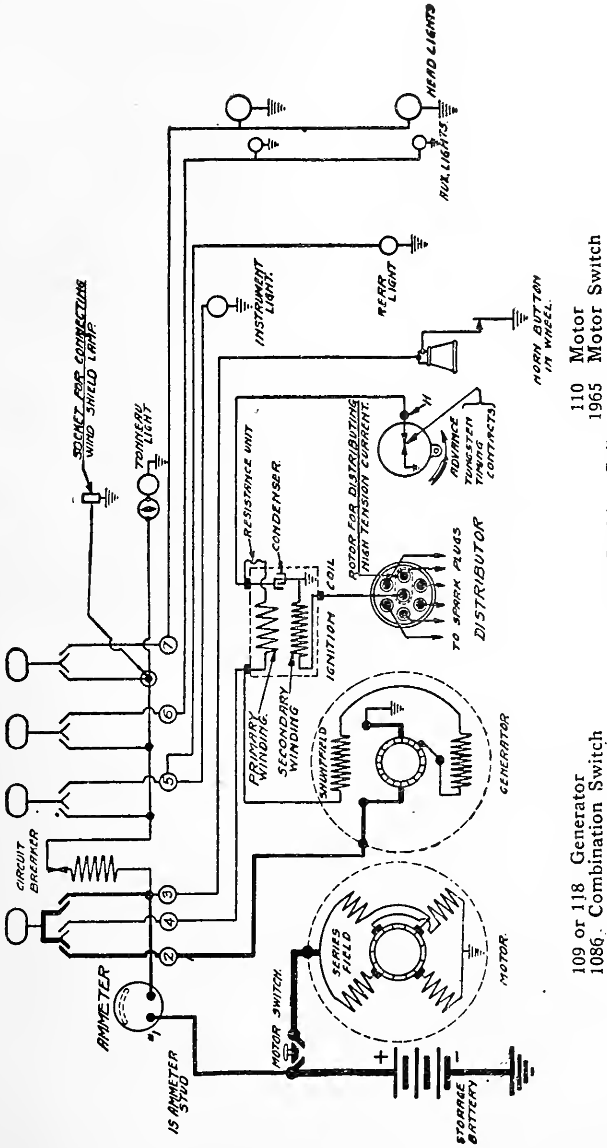
1914 Premier—Model M—Remy System



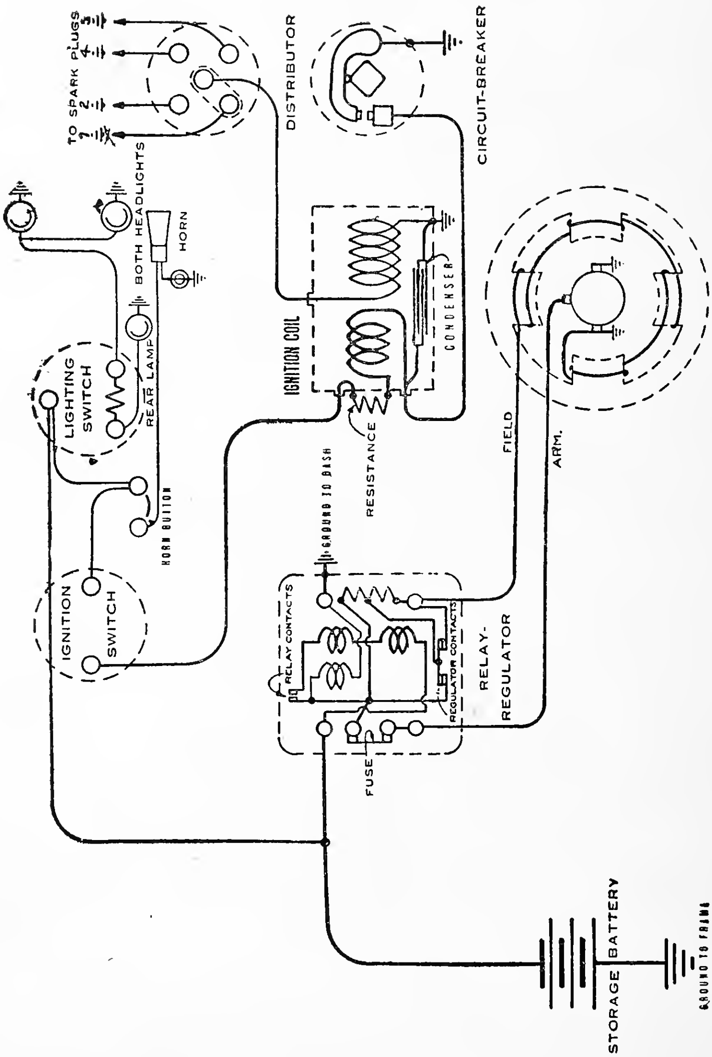
1915 Premier—Model M-J—Remy System



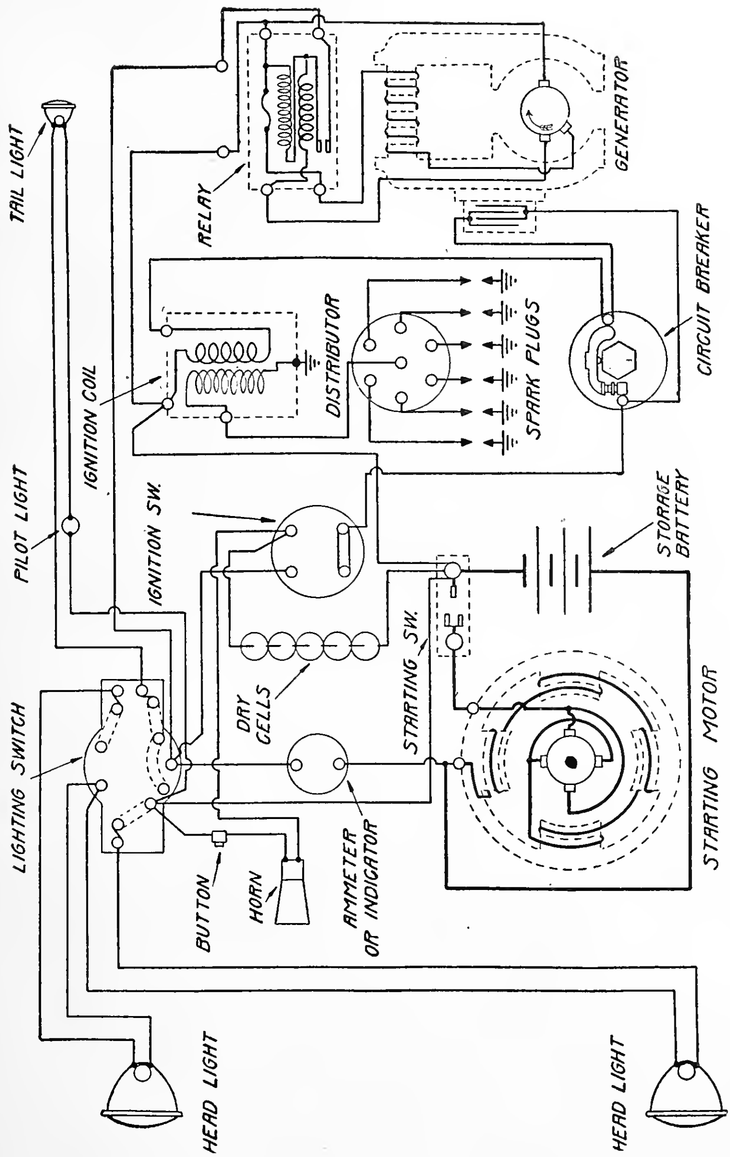
1915 Premier—Model M—Remy System



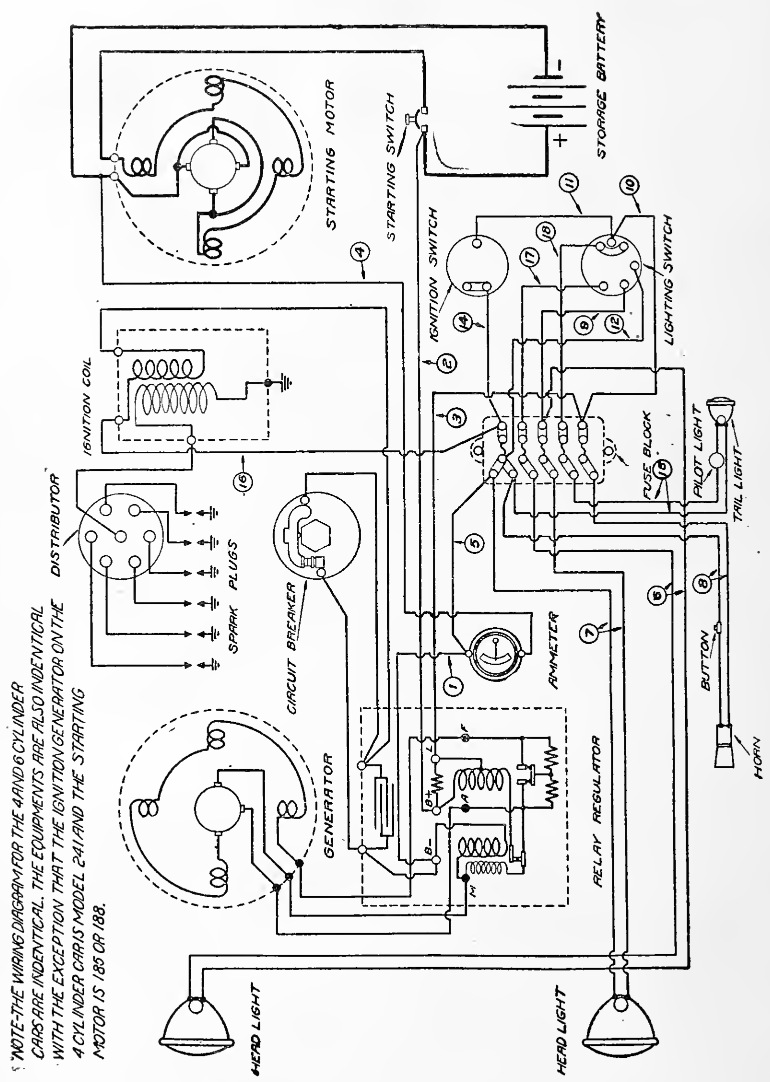
Premier Motor Corporation—6-B—1917 Delco System



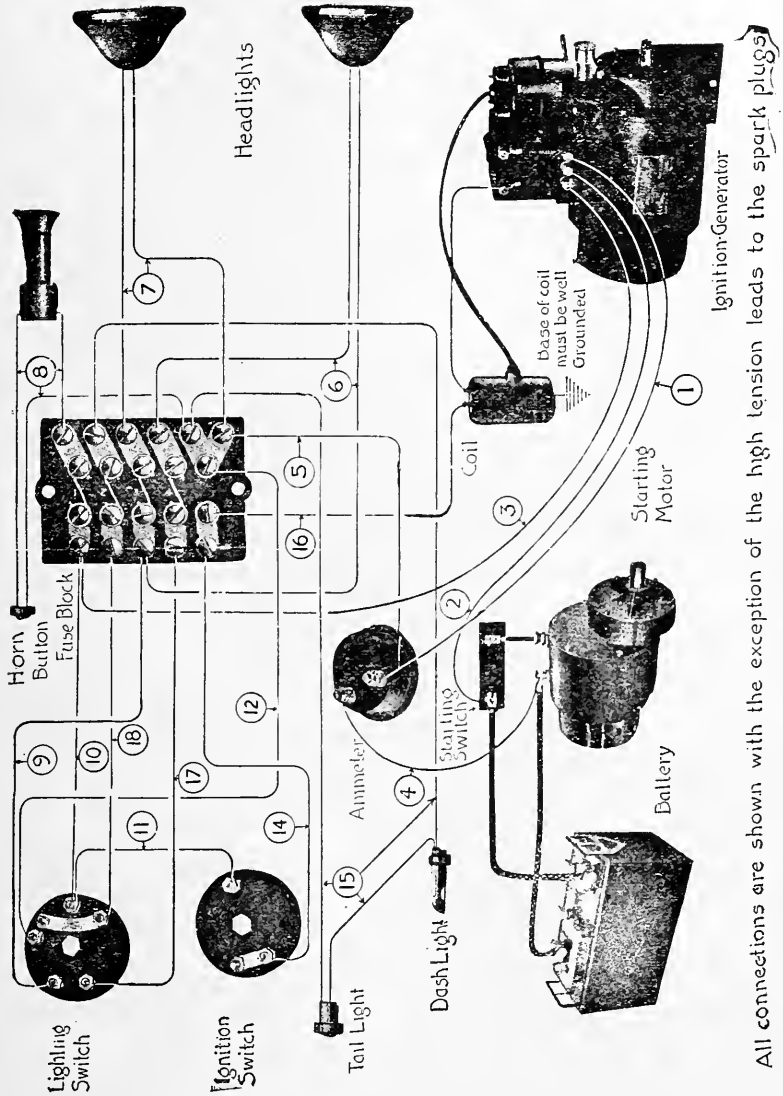
Republic Motor Truck—Models 8 and 9—Remy System



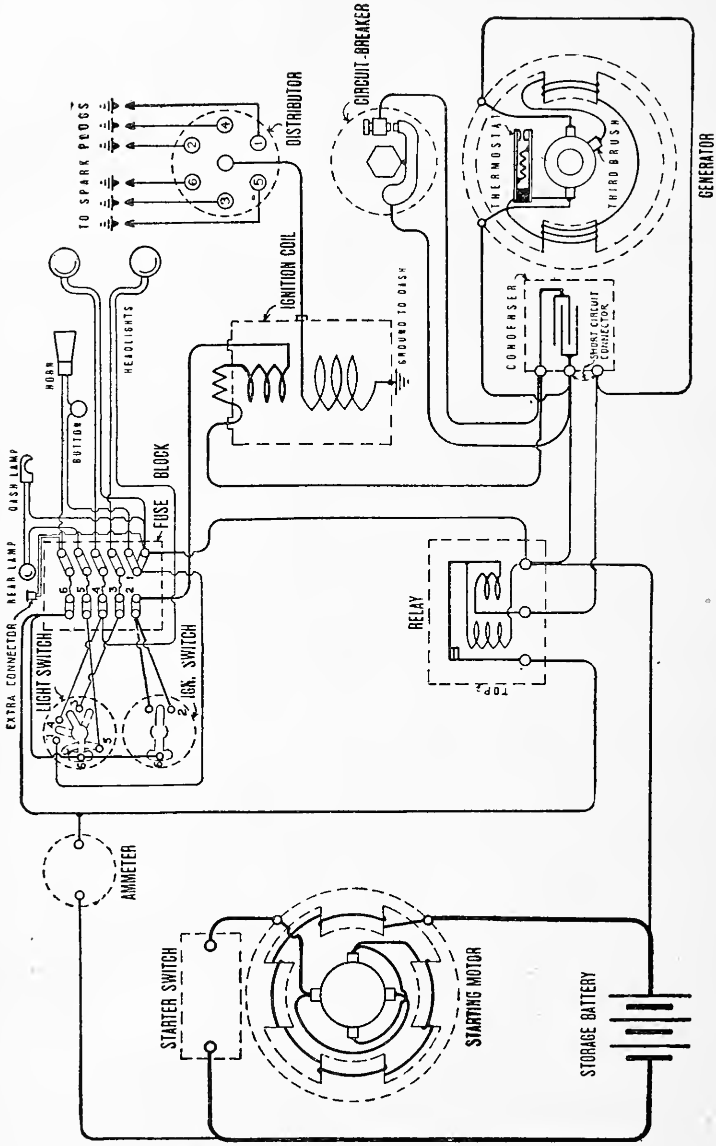
Reo 1914-15—Remy System



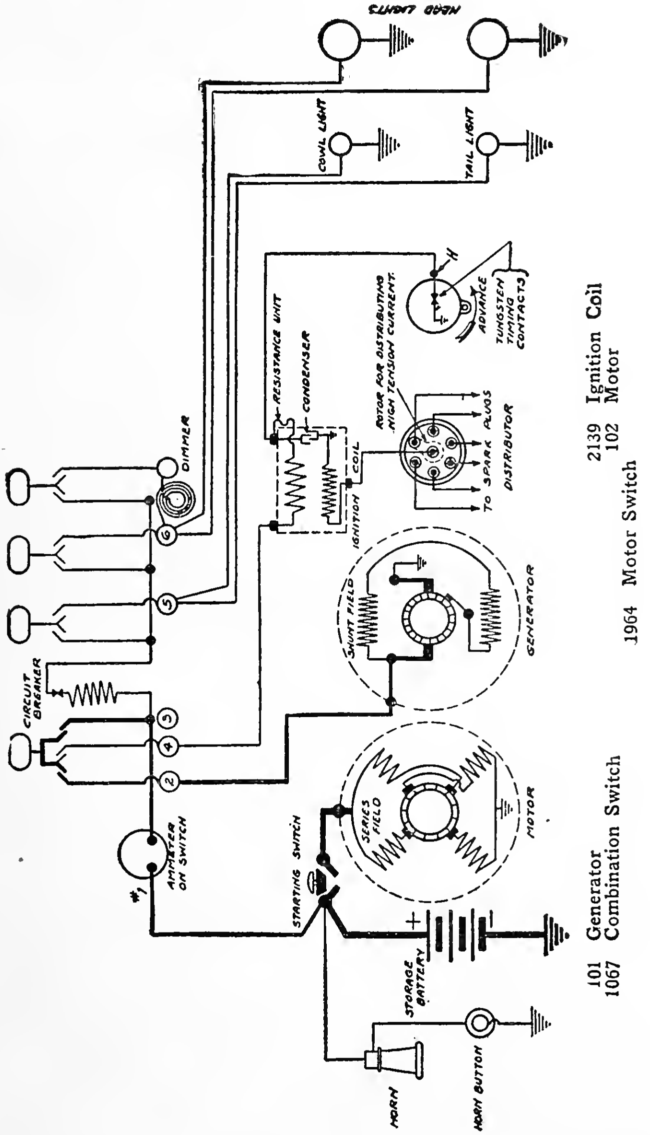
1916 Reo—Remy System



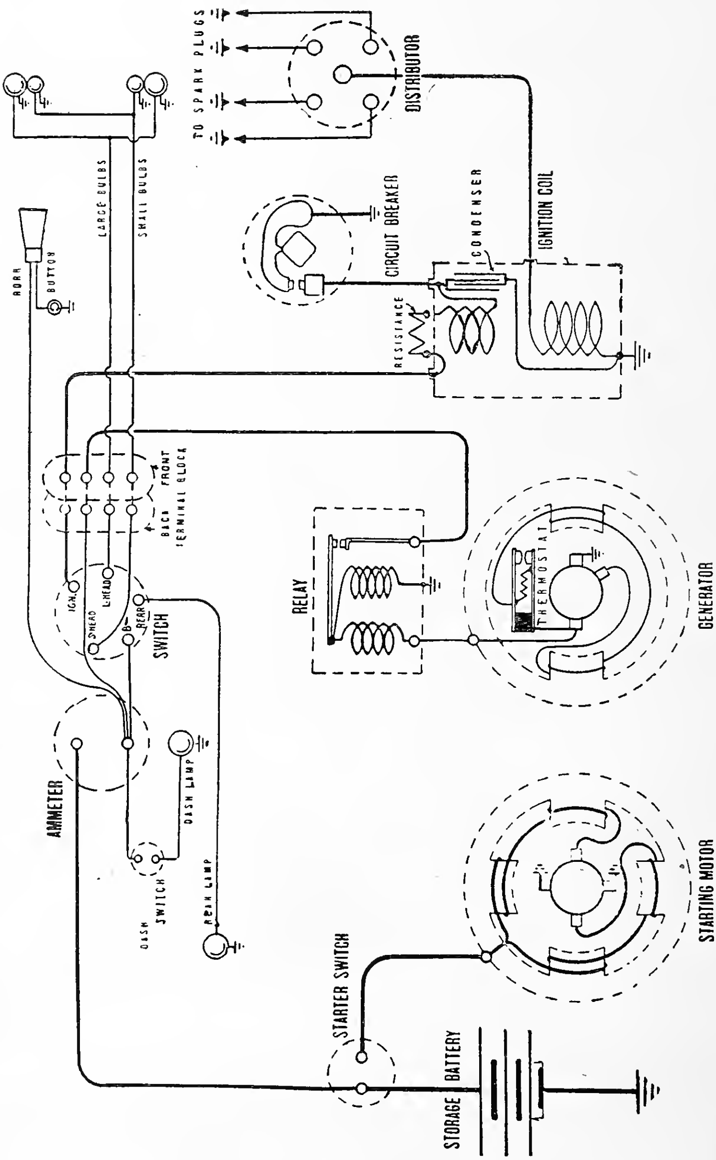
1916 Reo—Remy System



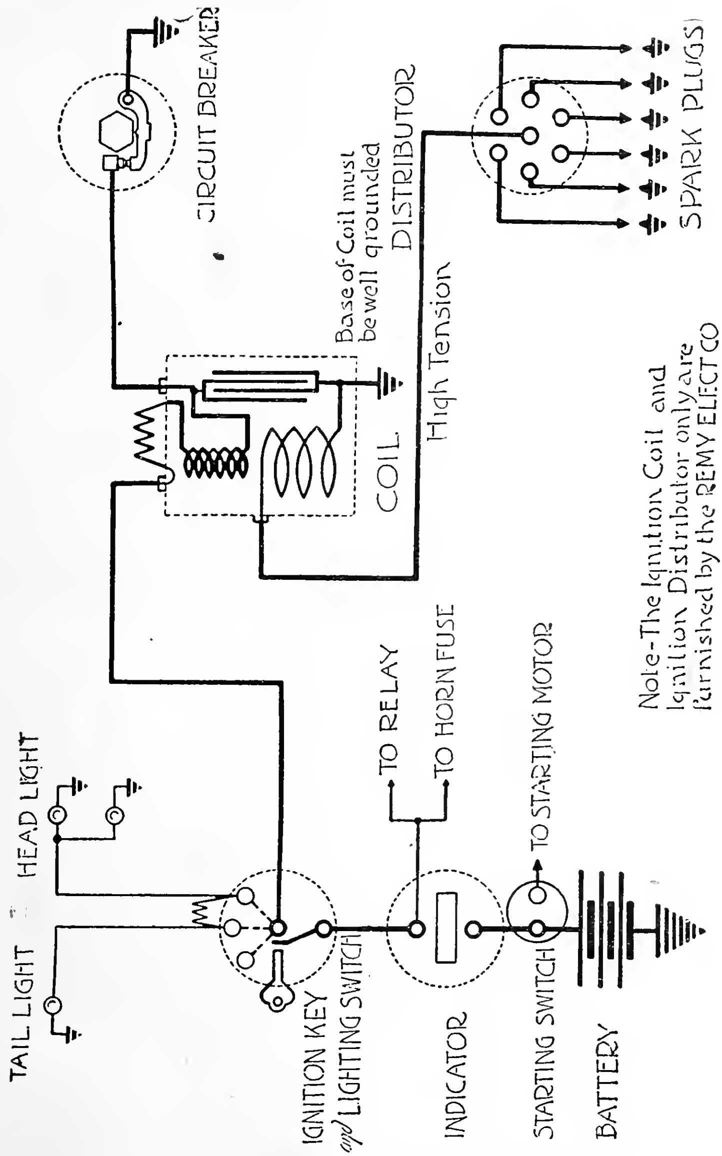
1917 Reo—4 and 6 Cylinder—Remy System



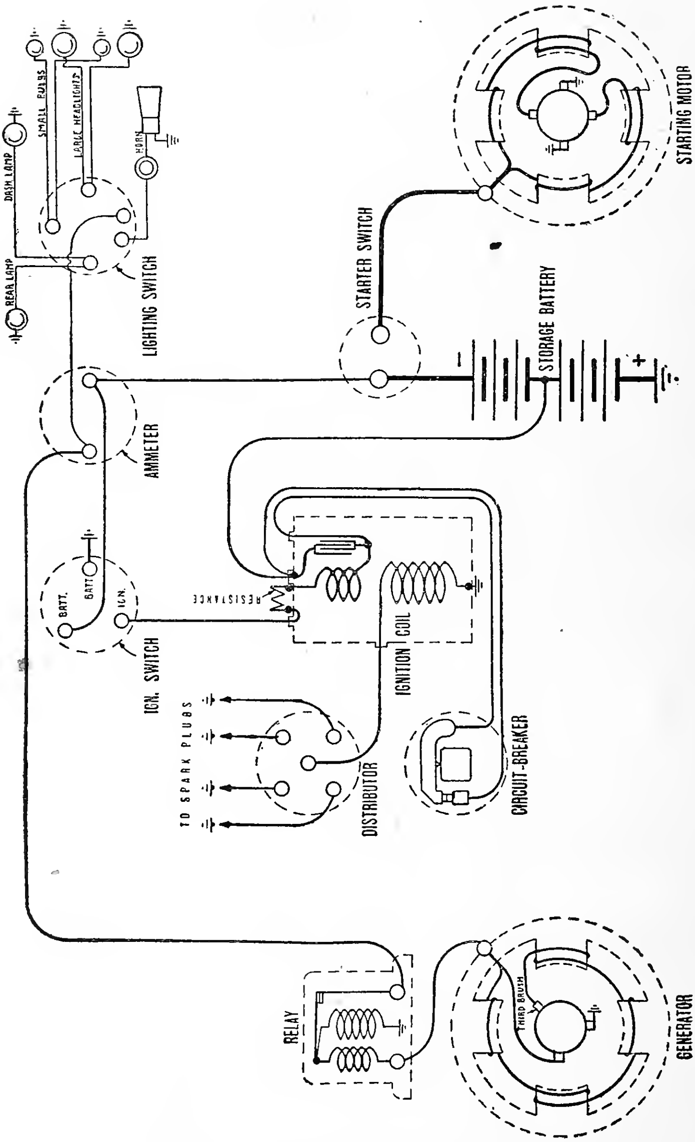
Riddell Coach & Hearse Company—1917 Delco System



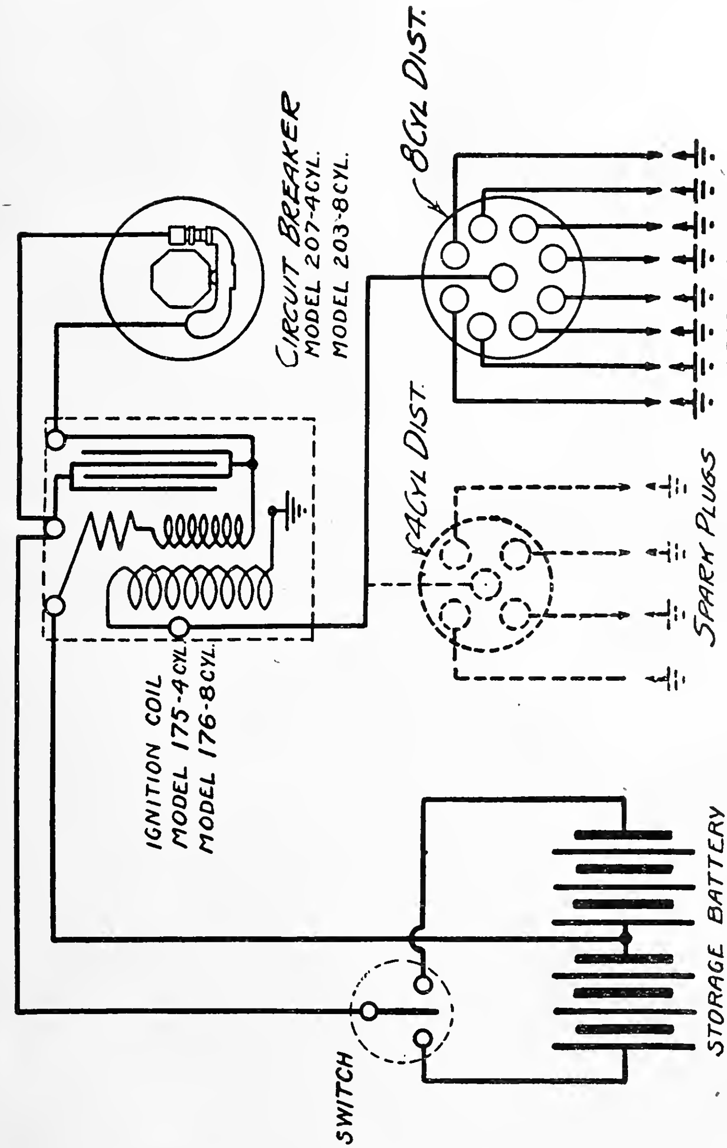
Scripps Booth—Model G—Remy System



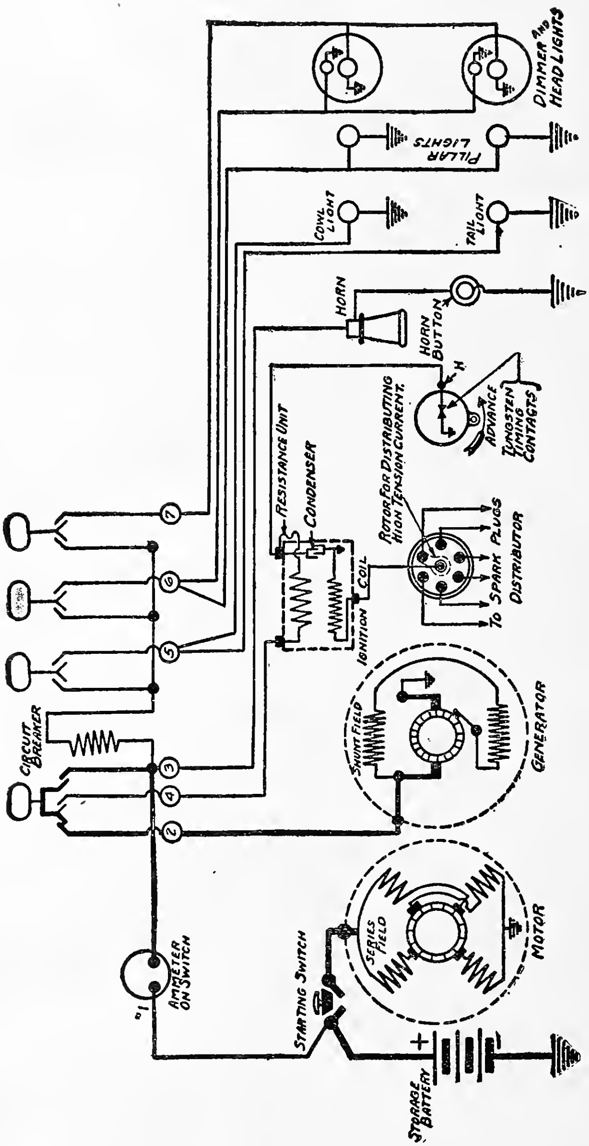
Saxon 1916 and 1917—Remy System



Stearns S. L. K. 4—Remy System

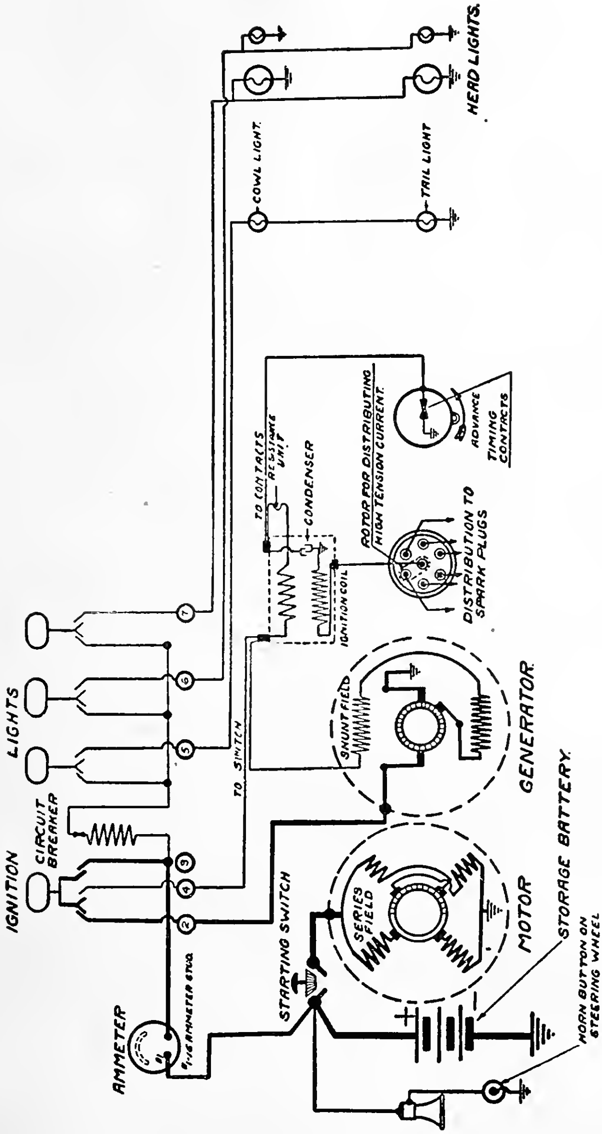


Stearns 1916, 1917 and 1918—Remy System



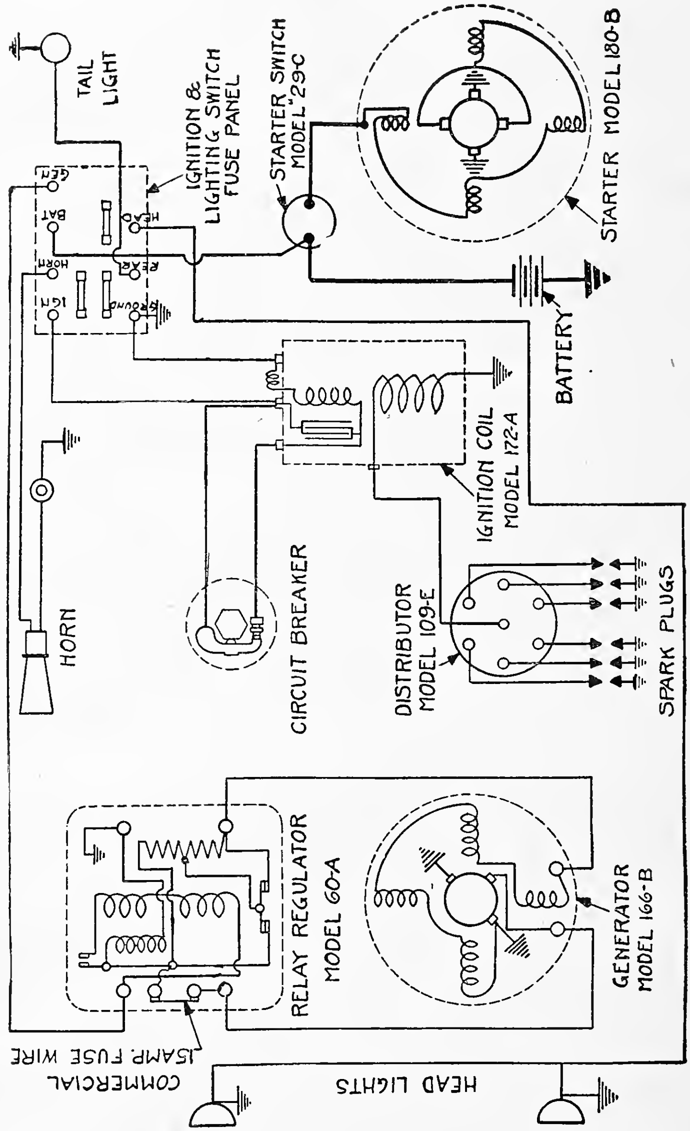
101 Generator
1066 Combination Switch
2139 Ignition Coil
102 Motor
1965 Motor Switch

Sayers & Scovill Company—Model—1917 Delco System

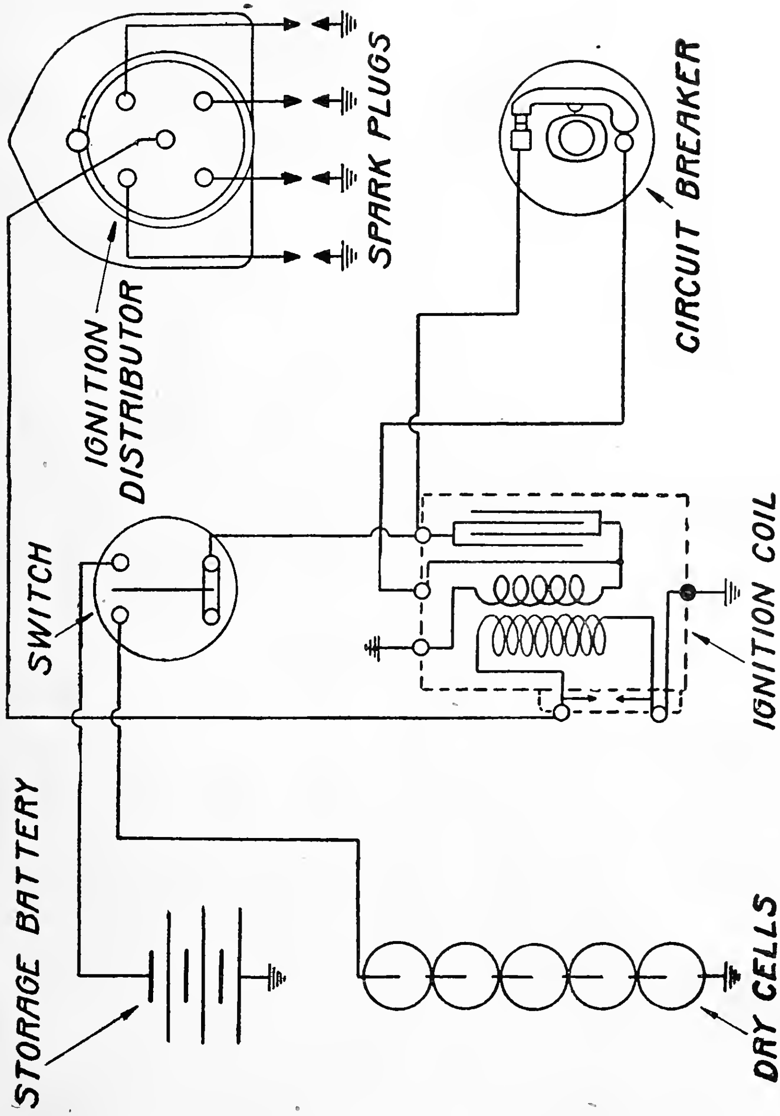


105 Generator
1081 Combination Switch
1964 Starting Switch
2139 Ignition Coil
106 Starting Motor

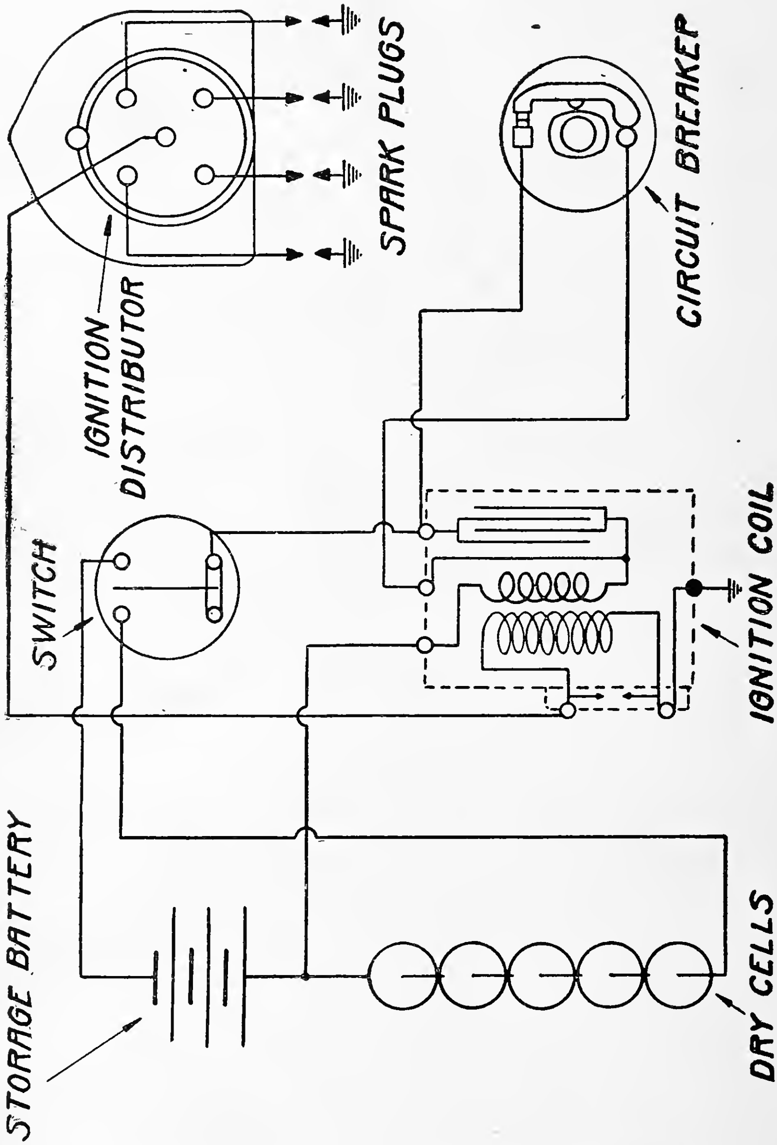
Stephens Motor Branch of Moline Plow Co.—1917 Model—Delco System



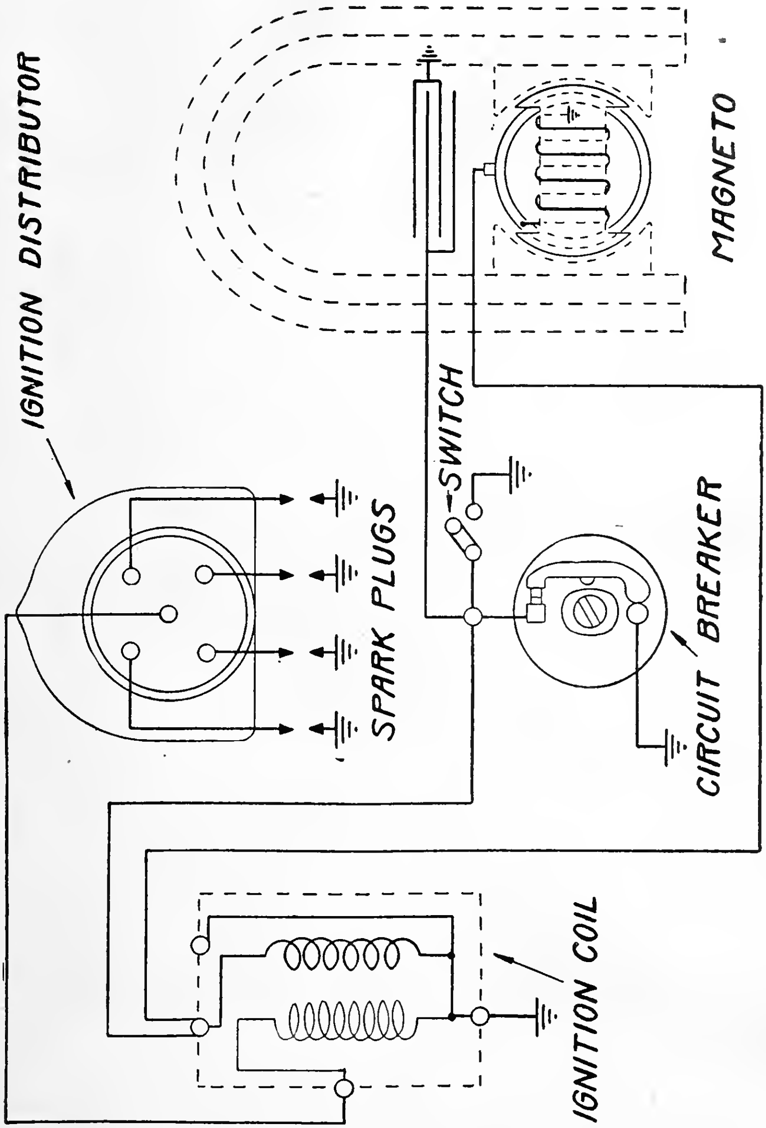
Sun Light Six—Remy System



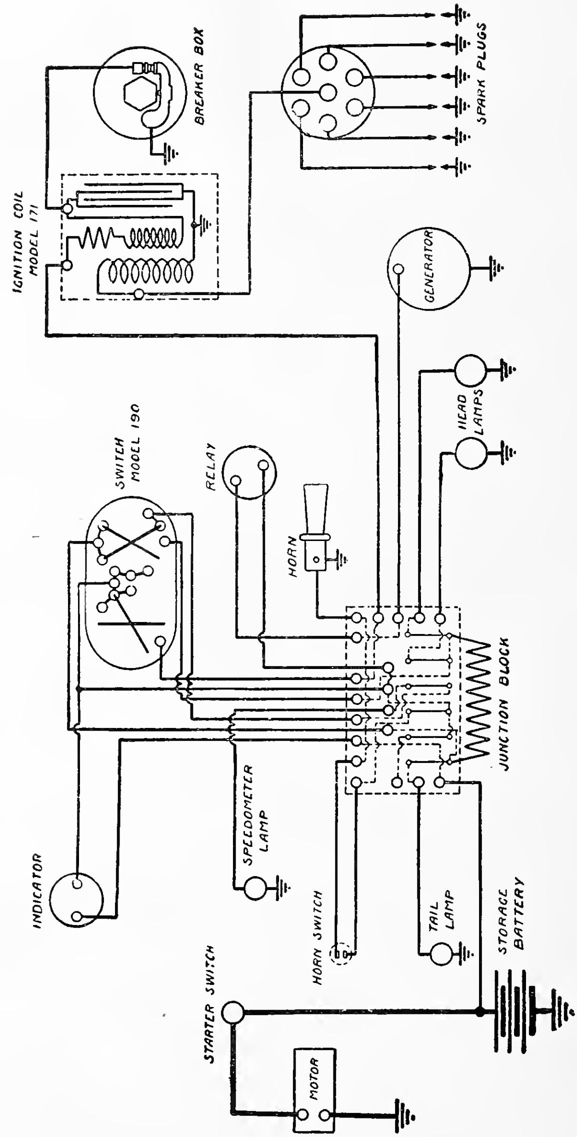
1914 and 1915 Studebaker—Grounded Battery—Remy Ignition



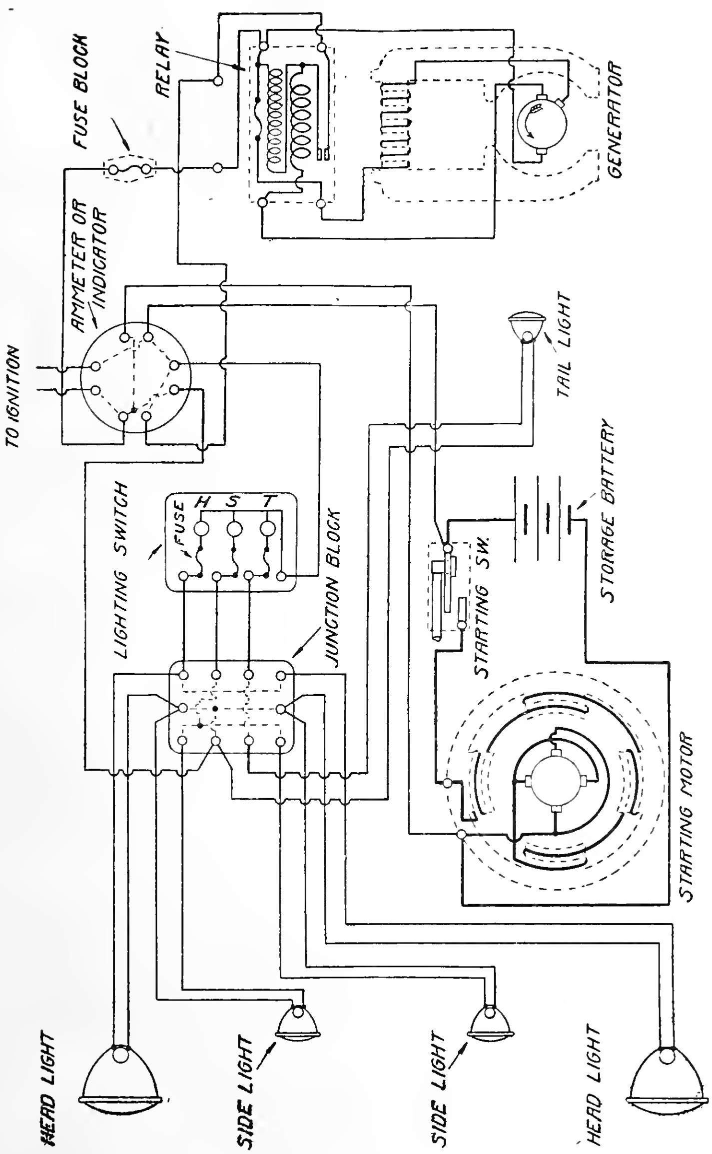
Studebaker 1914 and 1915—Ignition—Remy System



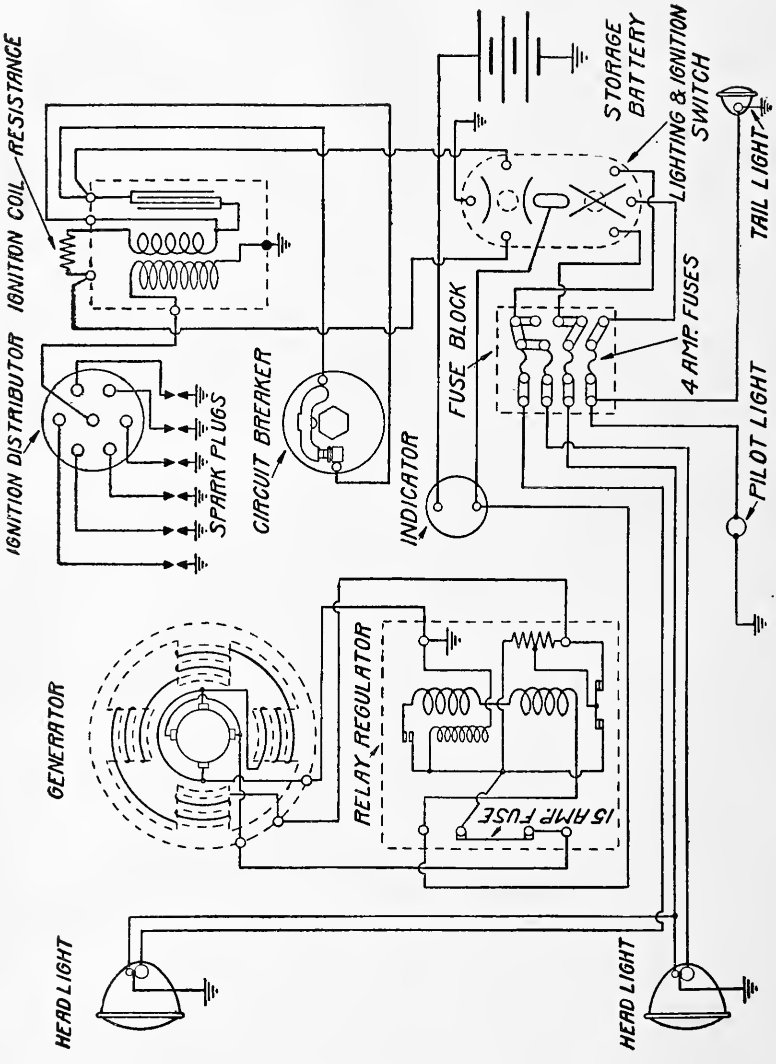
1916 Studebaker Street Flusher—Remy Ignition



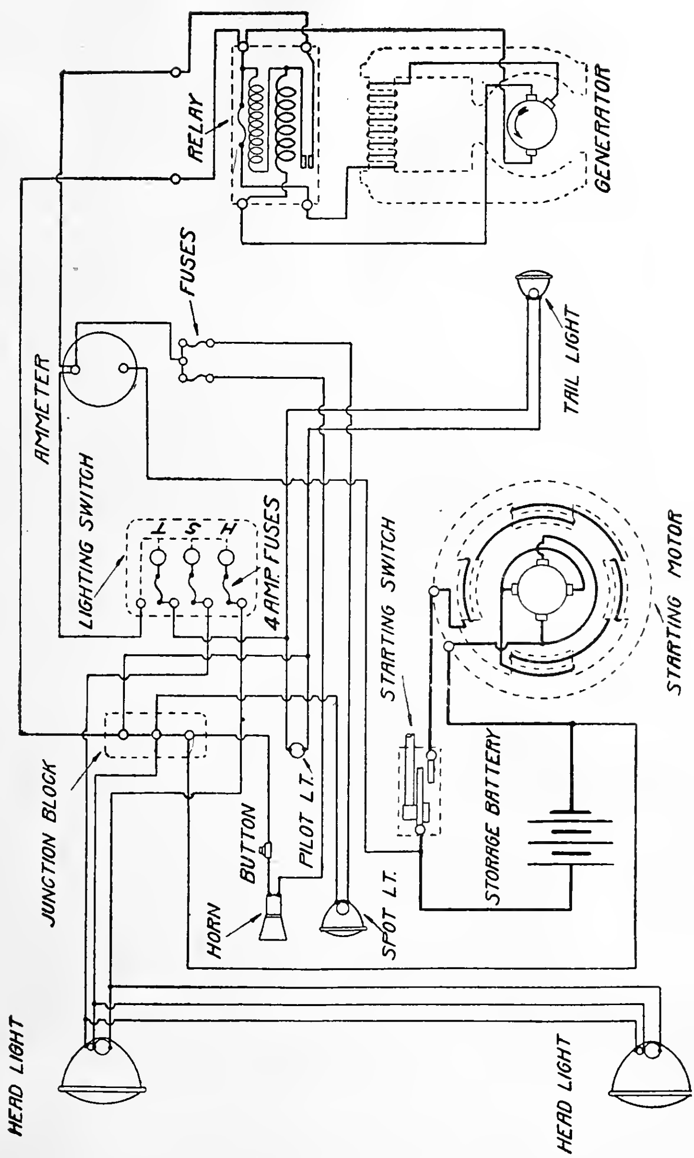
Studebaker 1916 and 1917—Remy Ignition



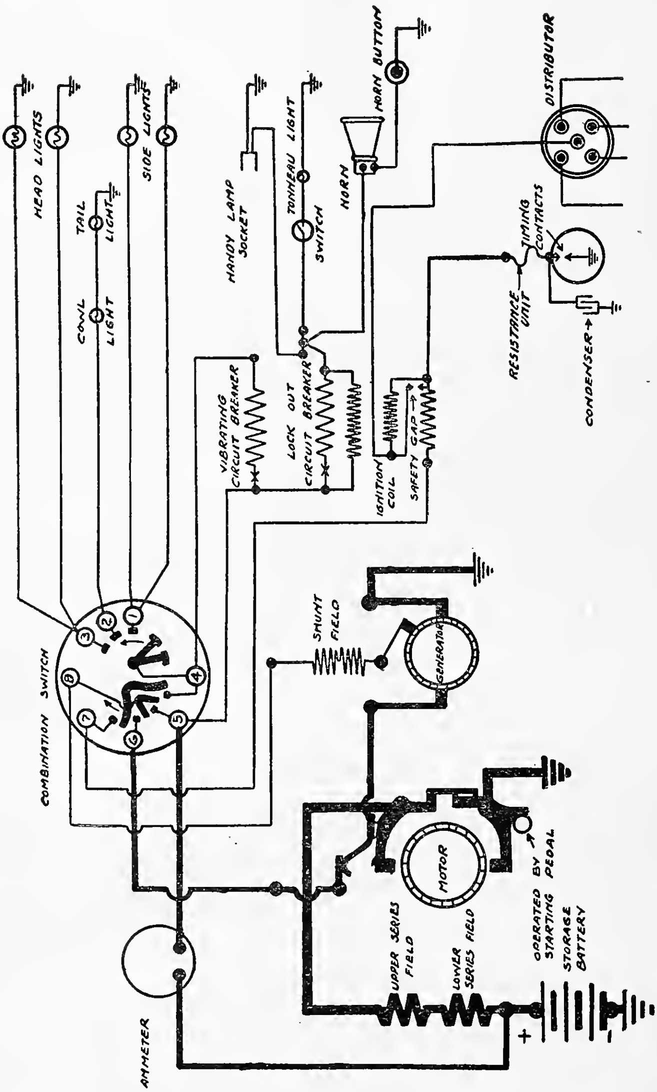
1914 and 1915 Stutz—Remy System



1916 and 1917 Sweeney Tractor—Remy System

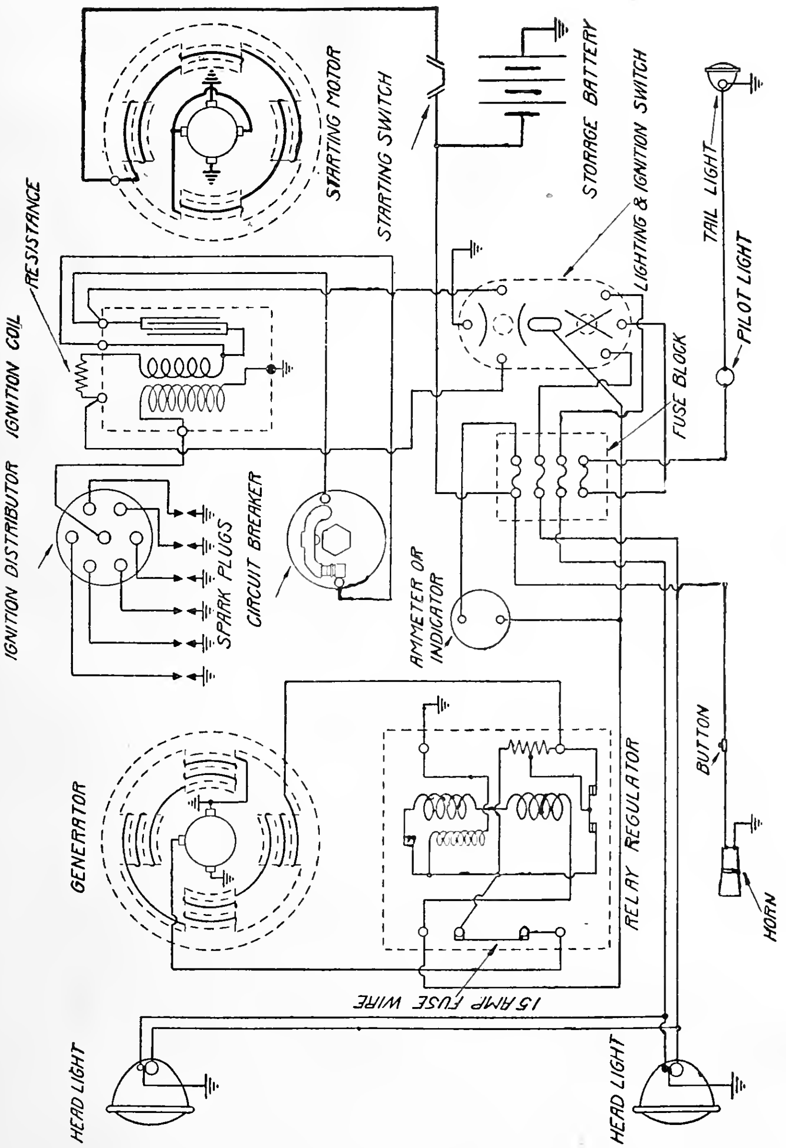


1916 and 1917 Stutz—Remy System

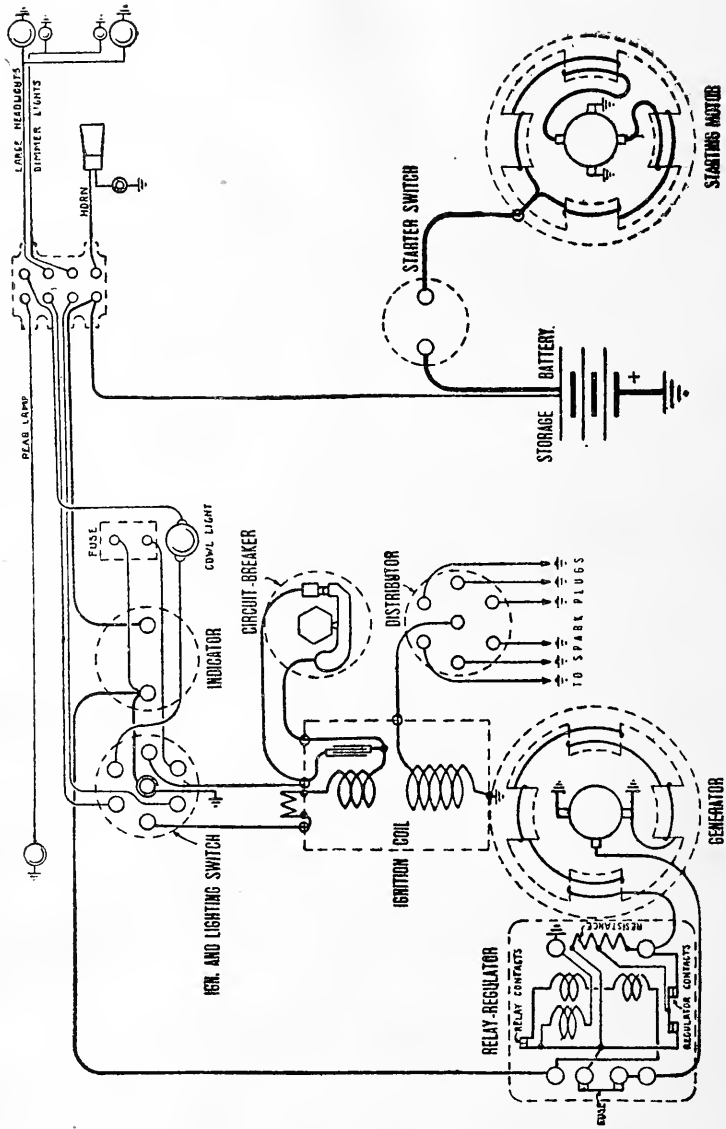


112 Motor Generator
1084 Combination Switch
5705 Circuit Breaker
5157 Distributor
2116 Ignition Coil
11663 Motor Clutch

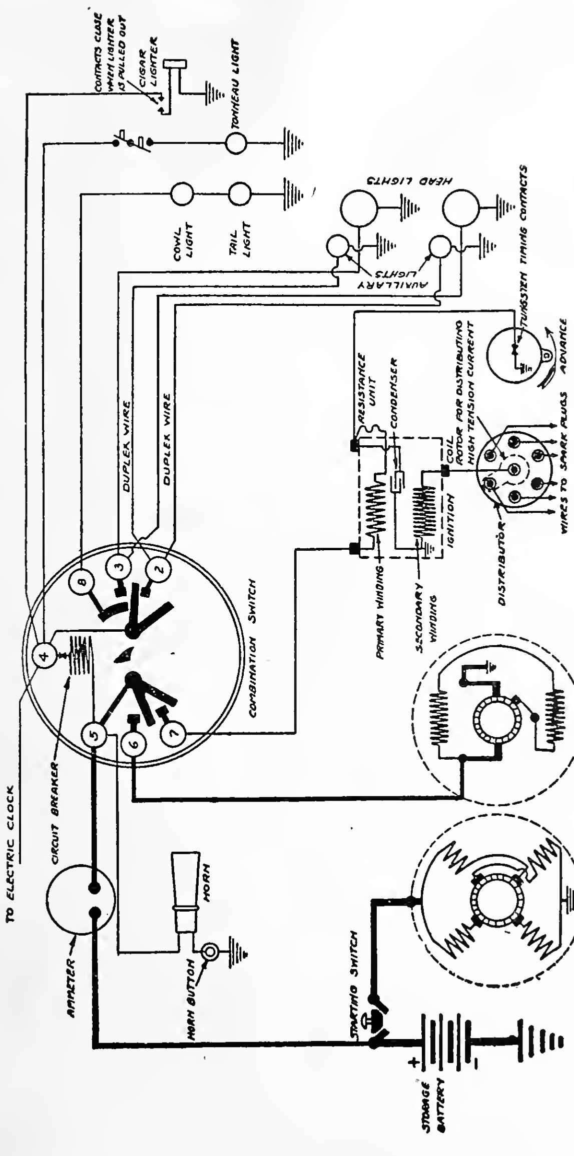
Trompenburg—Amsterdam, Holland—1917 Delco System



Velie 22—1916—Remy System



Velie—Model L-28—Remy System



101 Generator	1079 Combination Switch
2139 Ignition Coil	6058 Ammeter
1964 Motor Switch	102 Motor

Westcott Motor Car Company—Series 17—1917 Delco System